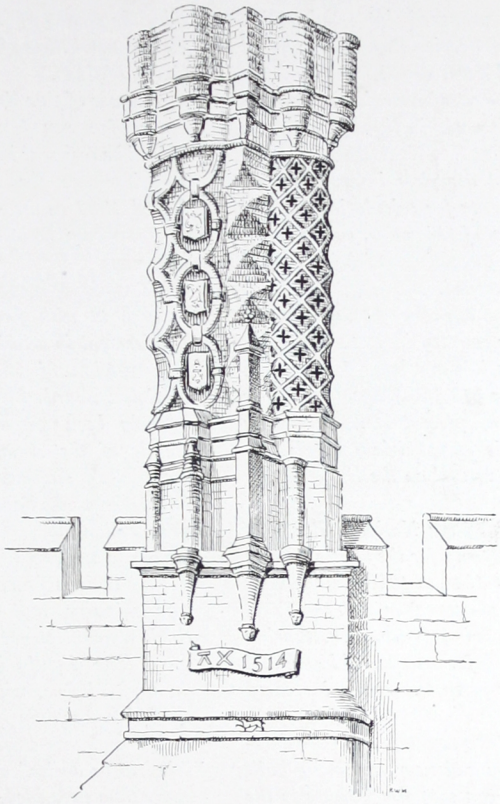
115-16.

A.I.A. File Number 5h

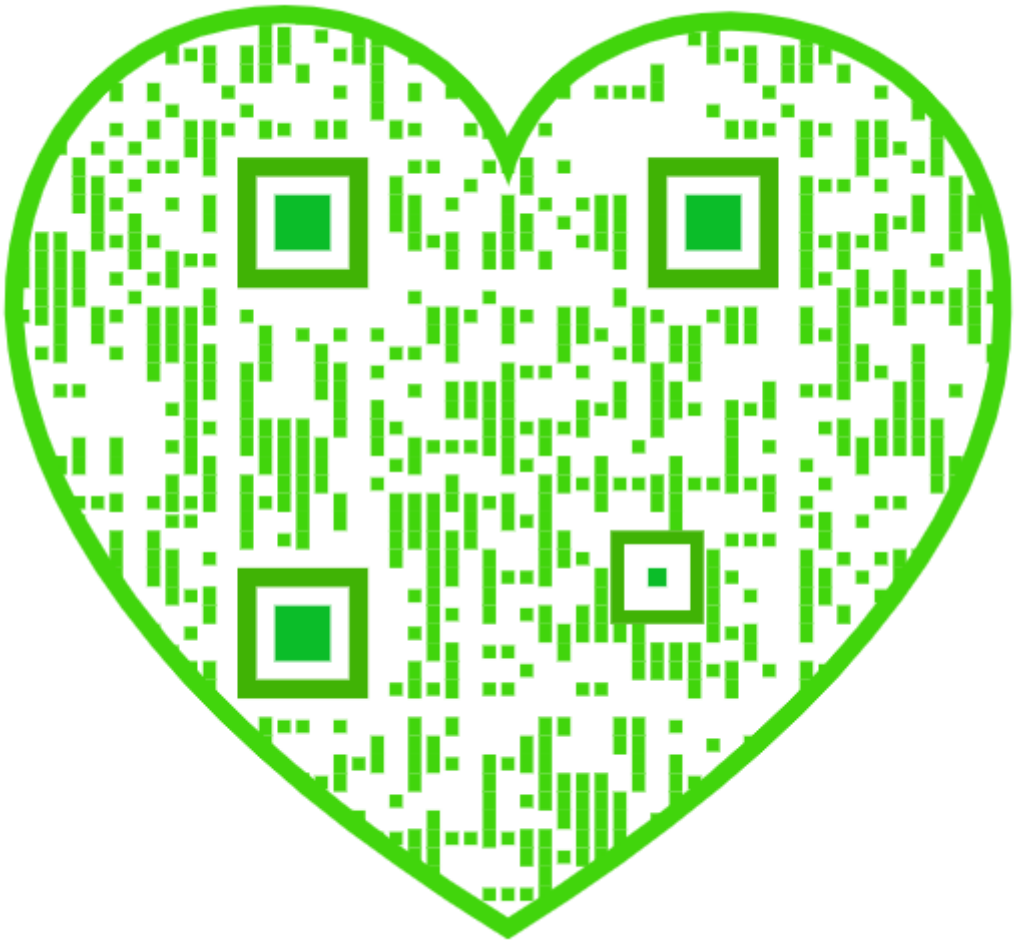


FLUES AND FLUE LININGS

with Related Data on

CHIMNEYS AND FIREPLACES

A.I.A. File Number 5h



PREFACE

(For CONTENTS see INDEX, pages 30-31)

This publication, prepared in collaboration with the Structural Service Bureau, is offered to architects, engineers, constructors and the general public in the interest of restraining fire and the products of combustion within lined flues where they properly belong.

In it is also included complete information on flue linings and related data for calculating sizes of flues, determining heights of chimneys, construction of fireplaces, and other information which it is hoped will be helpful to all concerned.

The latest statistics available show that, quite aside from the loss of life, this country in 1922 permitted an aggregate loss of materials and labor for building construction of more than $18,550,433 from a cause of fire admittedly strictly preventable. "Defective Chimneys and Flues" is responsible for this tremendous waste, which is second on the list of major fire causes.

The Actuarial Bureau of the National Board of Fire Underwriters is authority for the statement that during the six years from 1915 to 1920 this "strictly preventable" fire hazard was the cause of $71,037,084 worth of material wealth being destroyed. Allowing the usual conservative 25% for unreported losses and those upon uninsured property, the total is increased to $88,796,355.

Everywhere throughout the country, there are thousands of unsafe chimneys and new ones being built every day which form a constant fire menace to the occupants of buildings.

The reason for this lies in the natural and somewhat excusable ignorance of the average citizen as to how his or her chimney is built and as to what constitutes a safe chimney and flue, as well as to the availability and economy of flue linings. The purpose of this publication is, therefore, to provide everyone with the means of judging the proper, safe and efficient construction of chimneys and fireplaces and the lining of flues.

*The use of flue linings is required by the building codes of many forward looking communities and should be required by all. "Recommended Minimum Requirements for Small Dwelling Construction" issued 1923 as the Report of the U. S. Department of Commerce Building Code Committee, states "all chimneys * * * * * except chimneys having solid brick walls 8 inches or more thick shall be lined throughout with fire-clay flue lining." The same requirement is contained in "An Ordinance for the Construction of Chimneys, Recommended by the National Board of Fire Underwriters" and has more recently been proposed for incorporation in the "Code of the American Society of Heating and Ventilating Engineers." To these authorities and to all others who have so generously cooperated in the preparation of this document the appreciative thanks of the compilers is heartily extended.*

Flue linings provide the best means of assuring a safe chimney, and their use should be universal. Such a requirement cannot be considered burdensome. The slightly increased expense, if any, over an unlined flue, with all of its attendant dangers, would be more than justified by the prospective saving in life and property, to say nothing of the peace of mind to be derived and the saving in masonry and space thus permitted.

Flue linings are only one product of the member companies of the Eastern Clay Products Association, whose names are listed on the back cover of this book. These companies also manufacture chimney tops, sewer pipe, copings, septic tanks and other clay products. Separate publications describing each of these may be secured by addressing the

EASTERN CLAY PRODUCTS ASSOCIATION
HENRY T. SHELLEY, SECRETARY-MANAGER
906 COLONIAL TRUST BUILDING
PHILADELPHIA, PA.

Reprinted, March 1925
First Edition, December, 1924

COPYRIGHT, 1924, BY STRUCTURAL SERVICE BUREAU
D. Knickerbacker Boyd, Consulting Architect

Price 50 cents

OCT 29 '25

FLUES AND FLUE LININGS
with related data on
CHIMNEYS AND FIREPLACES

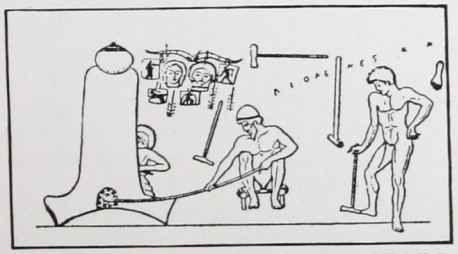
THE history of the chimney is clouded in the obscurity of the past. There is a legend which states that a Grecian king once directed his prime minister of feasts to prepare for a great festival. The custom in those days was to have large fires in holes in the ground and over these to roast the meats and prepare the other foods for the banquet. This was very satisfactory in dry weather, but now it had rained for many days and the pits were filled with water. There was nothing to do but build the fire in a hut. This was done and soon the blazing fires and dense smoke drove the prime minister and his slaves from the place.

They waited outside for the smoke to clear away so that they might rush in and put the meat on the fire, but as they waited they noticed a thin column of smoke curl up from the center of the roof, and then more and more smoke followed until the hut was free of smoke.

The superheated air had risen to the roof in a column and concentrating in one spot over the fire, had scorched a hole in the damp roof and the smoke had rushed through. Thus, according to the legend, Nature had helped man to observe the first principles of chimney construction. Like so many chimneys of today, unfortunately however, this was not a safe or a lasting one.

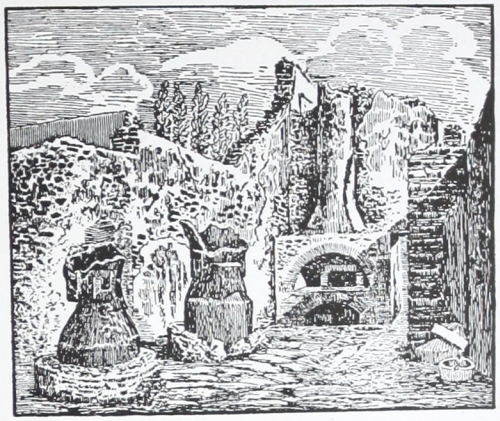
Origin of the Flue:

The first chimney of which there are any drawings was introduced into a smelter by the Greeks in 300 B. C. In the ruins of Pompeii there has been found a chimney in a bakery constructed about 75 A. D. By 1347 apparently several large cities of the period had adopted chimneys for there exists a record of many being overthrown in Venice by the earthquake of that year.



Courtesy Journal A. S. of H. & V. E.

FIG. 1. A GREEK CHIMNEY, 300 B.C.



Courtesy Journal A. S. of H. & V. E.

FIG. 2. CHIMNEY IN A BAKERY AT POMPEII, 75 A. D.

Tracing the history of the chimney in this brief outline, we find that the principal buildings of Europe contained examples of this feature of construction, many of which are maintained today as monuments of architectural splendor. The chateaux of France and the manor houses of England had elaborate chimneys, many of them of brick or stone, handsomely designed and executed with rich carvings to carry out the architectural effect of the buildings.

In America the colonists constructed chimneys for the fireplaces of the material closest at hand. In some cases, this was stone or brick and sometimes even of wood, lined with mud or mortar.

The First Flue Lining:

This last mentioned material was satisfactory until the heat baked the mud and charred the wood behind the lining to such a degree that the material cracked and fell off. Then there was liable to be a fire and gaining experience from his loss the owner in erecting a new cabin was sure to build a stone or brick chimney with massive masonry walls.

The design of these chimneys, low as they were, were more or less influenced by rule of thumb methods and the walls were made of a thickness suitable to the material available. In some cases, the walls were thicker than necessary and in many were far too thin. The natural result with these thin walled, unlined flues was

ID 89-18487 TCF

that the heat of the fire and the fumes from the combustion, combined to disintegrate the mortar in the joints of the masonry. A hole opened and through this, sparks and heated air often found their way to the surrounding woodwork and were the cause of many most destructive fires.

Thus originated the demand for a satisfactory lining for the chimney; a lining which would not crack from heat and which could be made in such lengths as would reduce the great number of mortar joints and at the same time produce a smooth surface to minimize friction and facilitate the passage of smoke and gases.

Almost from the first records of chimneys, the necessity for some kind of a lining for the flue was apparent. Throughout the history of chimney construction there has been a constant search for the proper material for this purpose. The peasants of Europe and the Colonists of America used mud or cow dung. The richer people used mortar or plaster.

At one time, the building codes of some of the cities in the United States required all thin walled chimneys to be "parged" or plastered on the inside. Today these same building codes absolutely forbid the use of "parging" as the fallacy of such construction, which loosens and drops, has become strikingly apparent as a source of great danger.

These codes now call for a flue lining of fire clay which has proved its resistance to fire.

FLUE LININGS

A FLUE LINING is exactly what the name implies, a lining for a flue,—and should never be called a "flue tile."

A flue is the space, hole or opening enclosed or surrounded by the masonry of a chimney not only for the purpose of providing for the escape or passage of smoke, fumes or gases, but to perform the duty of creating a draft to withdraw the same.

Such a passageway should be smooth and contain but few joints both from the standpoint of good draft as well as safety from fire.

Such results are obtainable only with flue linings.

As previously stated, a chimney having such lining possesses many advantages over one laid of any masonry, no matter how thick, without a lining.

In the preface to this publication brief reference is made to the great loss of life and property, which has resulted annually from defective chimneys and to codes and recommendations for linings to overcome these losses.

With adequate linings the dangers of fire from this cause are practically eliminated because fire clay flue lining:

1st: Is impervious to the action of the gases of combustion.

2nd: Protects the brickwork and its joints, thus preventing deterioration of the latter and providing a permanent structure.

3rd: Gives a smooth, clean chimney with but one cement joint every two feet as against ten joints in brickwork.

4th: Insulates the masonry, which is protected—kept cool—and all the heat and moisture is confined within the fireproof lining.

5th: Is easily installed and is economical.

In determining the sizes of flue linings, the manufacturers have been guided by the sizes of common and face brick.

The standard for these, adopted by the National Brick Manufacturers' Association, the Common Brick Manufacturers' Association, American Face Brick Association and finally by the American Society for Testing Materials, as the universal American Standard for common and face brick is 2¼ x 3¾ x 8 inches.

It should be noted that smooth face brick are produced in sizes approximately 3⅞ inches wide and that this size has recently been accepted as an additional standard at a conference held in the Division of Simplified Practice of the U. S. Department of Commerce.

The mistake should never be made of calling for "flue tile" or "terra cotta" flue lining, "clay" flue lining, "burned clay" flue lining, etc., but the words "fire clay flue lining" should always be used.

Fire clay flue lining is superior for chimney construction because it is made of a special mixture of clays thoroughly burned to withstand fire and heat, sudden or slow changes in temperature and all actions resulting from fire, smoke, gases or acids. It does precisely what unprotected mortar joints fail to do.

In preparing specifications it is suggested that architects should always require that a written guarantee be secured from the manufacturer that the flue lining fur-

nished, bearing his own trademark, is of "fire clay," made in accordance with the standards of the National Board of Fire Underwriters as set forth in the "Ordinance for the Construction of Chimneys."

These standards are also those of all member companies of the Eastern Clay Products Association and will be found in the "Specification for Brick Chimneys" on pages 27 and 28 of this publication.

Length and Sizes:

Flue lining is made in two-foot lengths (except the larger round linings which are 2′ 6″) and in various sizes suited to different requirements.

Lengths can be shortened as occasion requires by filling the flue lining with dampened sand and tapping a sharp chisel with a hammer around the lining along line where cut is desired. In this manner it can be cut to any length or at any angle.

The dimensions as before stated are figured on the basis of brick sizes so there should be no difficulty whatever in building up the chimney and the stack of the flue lining together.

Any variation in sizes of brick according to localities may be taken up in the mortar joint.

The standard sizes in which the various types of flue linings are manufactured are given in the tables on pages 6 and 7. Permissible variations are also given in the tables and are described in the note below.

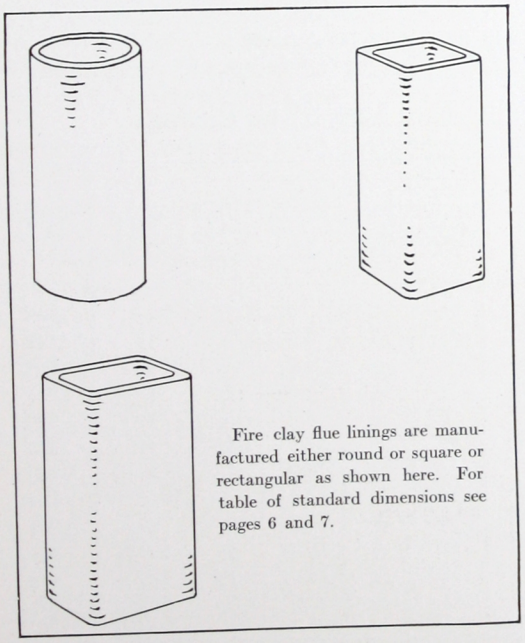
Linings with round openings for stove, furnace or heater pipes are carried in stock by almost all dealers in building supplies.

Those linings with square openings for registers are carried by many dealers but in some cases must be ordered from the manufacturer.

For lists of manufacturers with their addresses see page 32.

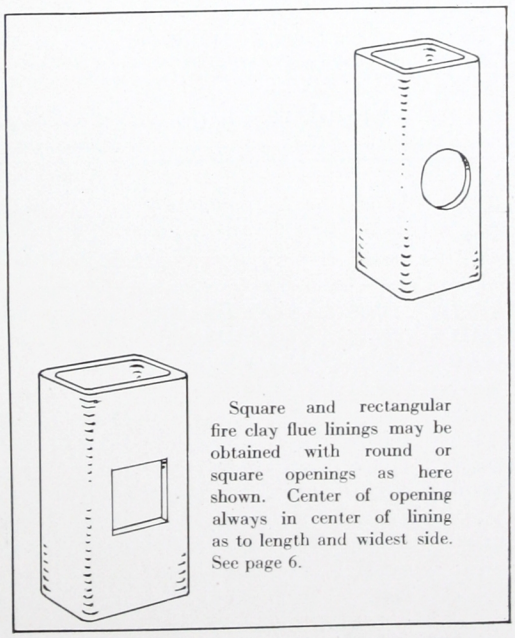
NOTE: The standard dimensions in the table of sizes are those aimed at by all Member Companies of the Eastern Clay Products Association. Due to the nature of clay products, a variation from these "nominal" sizes must be allowed for. The permissible variations are listed in the tables on pages 6 and 7, on the basis of shells being approximately uniform in thickness in any one length. Member Companies will maintain the nominal sizes as the average of annual output.

Types of Fire Clay Flue Linings



Fire clay flue linings are manufactured either round or square or rectangular as shown here. For table of standard dimensions see pages 6 and 7.

FIG. 3. PLAIN FLUE LININGS.



Square and rectangular fire clay flue linings may be obtained with round or square openings as here shown. Center of opening always in center of lining as to length and widest side. See page 6.

FIG. 4. OPENINGS IN FLUE LININGS

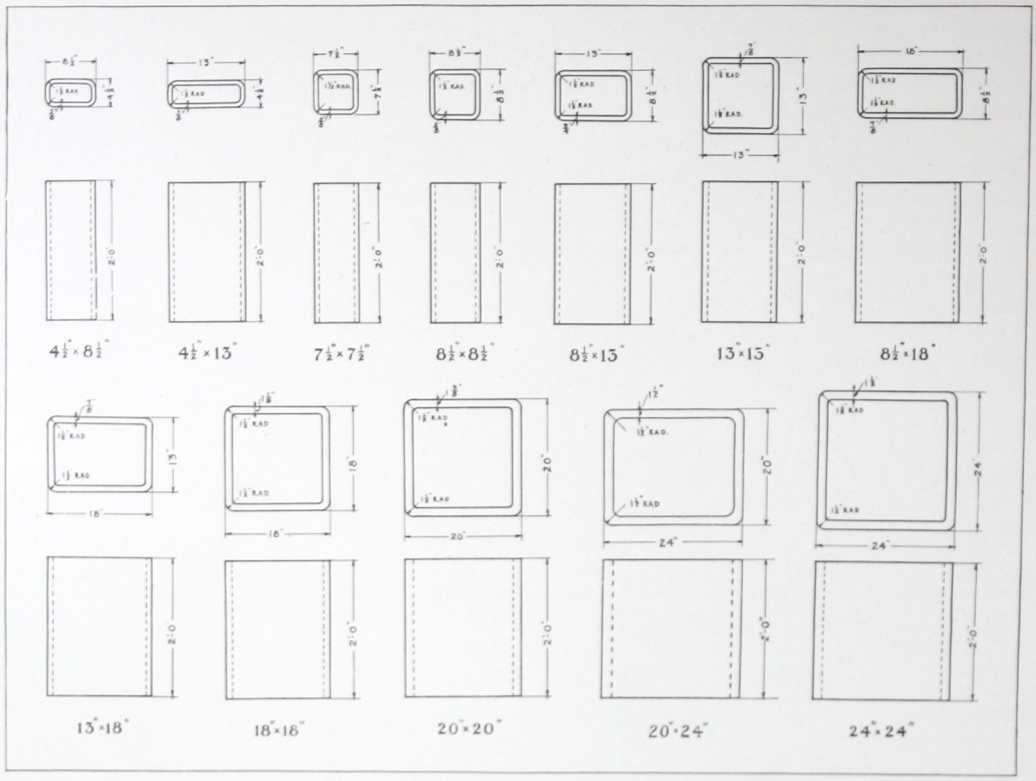


FIG. 5. STANDARD SIZES OF RECTANGULAR FIRE CLAY FLUE LININGS

NOTE: The standard sizes shown above are also manufactured with round openings for flue rings. The diameter of the opening is cut to suit the outside diameter of the proper size flue ring and allow ¼-inch clearance. Rectangular openings are not standard but can be furnished to order.

Standard Dimensions of Rectangular Fire Clay Flue Linings

NO ALLOWANCE FOR RADIAL CORNERS

Inside Dimensions of Flue Linings, Inches	Inside Cross Sectional Area of Flue Linings, Square Inches	Thickness of Shell, Inches	Outside Dimensions of Flue Linings, Inches	Outside Cross Sectional Area of Flue Linings, Square Inches	Cross Sectional Area of Shell, Square Inches	Length, Feet	Limits of Permissible Variation in				Approximate Weight per Foot, Pounds	Approximate Number Flue Linings per Car
							Length: Inches per Foot (—)	Thickness of Shell: Inches (±)	Actual Inside Cross Sectional Area Square Inches (±)	Actual Inside Size, Each Dimension Inches (±)		
3¼ x 7¼	23.56	⅝	4½ x 8½	38.25	14.69	2	¼	1/16	3.0	¼	14	1953
3¼ x 11¾	38.19	⅝	4½ x 13	58.5	20.31	2	¼	1/16	4.0	¼	19	1322
6¼ x 6¼	39.06	⅝	7½ x 7½	56.25	17.19	2	¼	1/16	4.0	¼	14	1784
7¼ x 7¼	52.56	⅝	8½ x 8½	72.25	19.69	2	¼	1/16	4.5	¼	18½	1335
7 x 11½	80.5	¾	8½ x 13	110.5	30.0	2	¼	⅛	5.0	¼	28	892
6¾ x 16¼	109.69	⅞	8½ x 18	153.0	43.31	2	¼	⅛	6.5	¼	37	675
11¼ x 11¼	126.56	⅞	13 x 13	169.0	42.44	2	¼	⅛	12.0	½	35½	709
11¼ x 16¼	182.84	⅞	13 x 18	234.0	51.16	2	⅜	⅛	14.5	½	52	482
15¾ x 15¾	248.06	1⅛	18 x 18	324.0	75.94	2	⅜	3/16	16.0	½	69	367
17¼ x 17¼	297.56	1⅜	20 x 20	400.0	102.44	2	⅜	3/16	18.50	½	102½	241
17 x 21	357.0	1½	20 x 24	480.0	123.0	2	⅜	3/16	19.5	½	115	166
21 x 21	441.0	1½	24 x 24	576.0	135.0	2	⅜	3/16	21.0	½	125	201

NOTE: The minus sign (—) alone indicates that the plus variation is not limited; the plus and minus sign (±) indicates variation in both excess and deficiency in dimension.

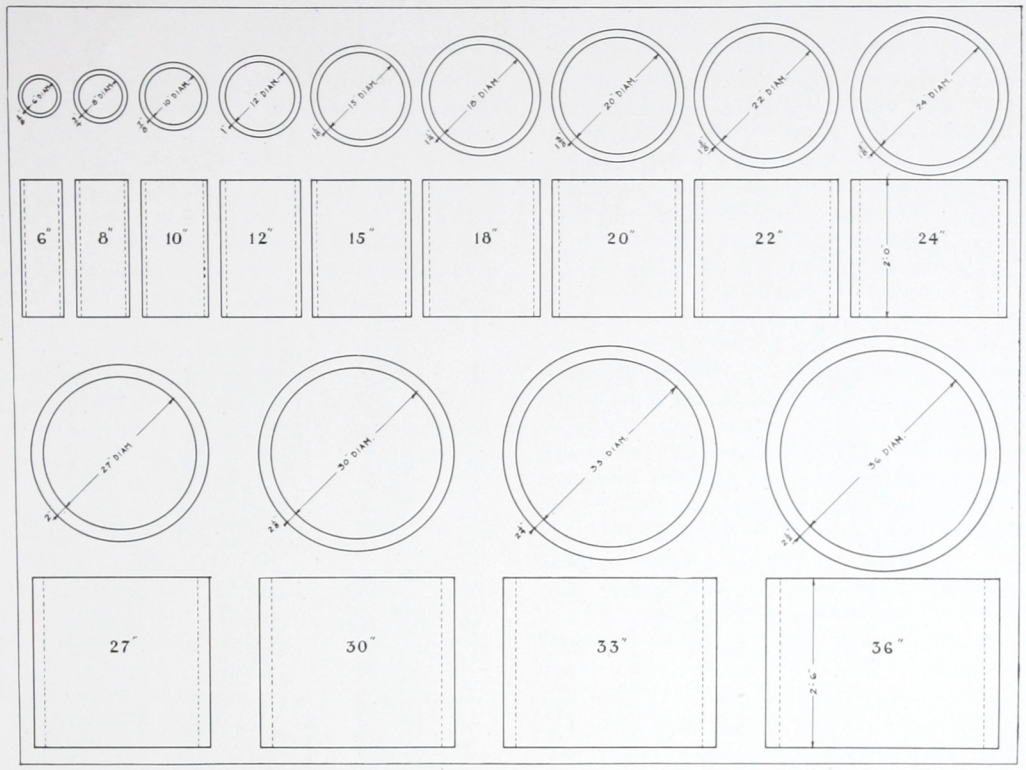


FIG. 6. STANDARD SIZES OF ROUND FIRE CLAY FLUE LININGS

NOTE. Round flue linings are not furnished with openings.

Standard Dimensions of Round Fire Clay Flue Linings

Inside Diameter of Flue Linings, Inches	Inside Cross Sectional Area of Flue Linings, Square Inches	Thickness of Shell, Inches	Outside Diameter of Flue Linings, Inches	Outside Cross Sectional Area of Flue Linings Square Inches	Cross Sectional Area of Shell, Square Inches	Length Feet	Limits of Permissible Variation In:				Approximate Weight per Foot, Pounds	Approximate Number Flue Linings per Car
							Length: Inches per Foot (—)	Thickness of Shell: Inches (±)	Actual Inside Cross Sectional Area: Square Inches (±)	Actual Inside Diameter Inches (±)		
6	28.27	5/8	7 1/4	41.28	13.01	2	1/4	1/16	2.40	1/4	12	2002
8	50.26	3/4	9 1/2	70.88	20.62	2	1/4	1/8	3.20	1/4	19 1/2	1269
10	78.54	7/8	11 3/4	108.4	29.86	2	1/4	1/8	4.00	1/4	27 3/4	953
12	113.0	1	14	153.93	40.93	2	1/4	1/8	4.80	1/4	39 1/4	629
15	176.7	1 1/8	17 1/4	233.7	57	2	1/4	1/8	6.00	1/4	54 1/4	463
18	254.4	1 1/4	20 1/2	330.0	75.6	2	3/8	3/16	14.40	1/2	71	350
20	314.1	1 3/8	22 3/4	406.4	92.3	2	3/8	3/16	16.00	1/2	87 1/2	288
22	380.13	1 5/8	25 1/8	495.7	115.57	2	3/8	3/16	17.50	1/2	127 3/4	198
24	452.3	1 5/8	27 1/4	583.2	130.9	2	3/8	3/16	19.10	1/2	129	193
27	572.5	2	31	754.8	182.3	2 1/2	3/8	3/16	21.40	1/2	213 1/2	116
30	706.8	2 1/8	34 1/4	921.3	214.5	2 1/2	1/2	3/16	23.80	1/2	261	95
33	855.3	2 1/4	37 1/2	1104.5	249.2	2 1/2	1/2	3/16	26.10	1/2	315	79
36	1017.9	2 1/2	41.0	1320.3	302.4	2 1/2	1/2	3/16	28.4	1/2	360	69

NOTE: The minus sign (—) alone indicates that the plus variation is not limited; the plus and minus sign (±) indicates variation in both excess and deficiency in dimension.

CHIMNEYS AND FLUES

THE first and primary purpose of a chimney is to provide a draft which will cause sufficient combustion and carry off the resulting smoke. Nature accomplished these two results, as described in the legend, by burning a hole through the roof of the hut. The Indian in our own country built his tepee of skins or cloth with a hole at the apex of the cone which it formed. Thus he allowed for a circulation of air and the escape of smoke.

FIG. 7. AN INDIAN TEPEE

The settler built his fireplace to accommodate large logs and then constructed his chimney more or less by guess work. Even today when the theory of drafts has been studied and rules laid down for the proper size of flues, many chimneys are built which fail to function satisfactorily because they are not of the proper cross sectional area. Another trouble with many chimneys is that the chimney is built too low.

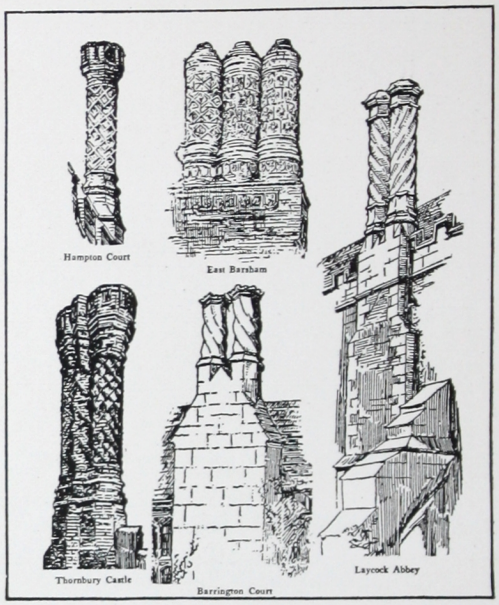
Draft:

Draft in a flue is caused by the difference in weight between a volume of the gases formed by the fire and an equal volume of air on the outside. Air expands as the heat increases and therefore the weight of its unit volume becomes less. The pressures at the base of the flue become unequal and the lighter gases rise in the chimney tending to equalize the pressure. This forms the draft and on this principle depends the action of the chimney.

Shapes of Flue:

It will be seen, therefore, that the most efficient chimney is one built perfectly straight, of proper height and adequate cross sectional flue area. The gases of combustion rise with a circular swirling motion and a round flue, for this reason, is considered by many authorities, to be the most efficient as it offers less resistance to the ascending column of smoke. An elliptical shape would be second choice for the same reason, but must be eliminated because of the difficulties presented in manufacture and in the construction of the chimney. Such oval flues are made only upon special order and involve considerable additional expense.

It is apparent from the foregoing that the square or oblong chimney is not effective over its entire cross sectional area, because the rising column does not fil-



Courtesy Journal A. S. of H. & V. E.

FIG. 8. TUDOR BRICK CHIMNEYS, ENGLAND, 16TH CENTURY

the corners. These forms, however, are used more frequently than the round, partly because of the greater cost of any type of masonry with round flue construction and the greater care which must be exercised to insure the complete filling of the corner spaces. In this connection, however, the greatest care should always be taken to completely fill with mortar the space between every flue and the surrounding masonry, otherwise there is liable to be leakage into the vacant spaces, with consequent injury to the draft and the effectiveness of the flue.

Certain of the best authorities on chimney construction, among them the American Society of Heating and Ventilating Engineers, believe that the "effective area" of a square flue is only the equivalent of the largest circle which could be inscribed therein. As an example, a square flue measuring 13 inches out-

side is 11¼ inches inside and has an actual inside area of 127 square inches. The largest circle which could be inscribed in this flue lining would have a diameter of 11¼ inches, making the "effective flue area" the area of this circle or 99 square inches. For a rectangular flue the effective area is usually determined by the formula $\pi \times (\frac{B}{2})^2 + B(A-B)$ in which A = the inside length and B = the inside width of the flue lining. A rectuangular flue with outside dimensions of 8½" x 13" is 7" x 11½" inside and actual inside area of 80.5 square inches. The effective area, however, according to the formula, is 70.28 square inches.

The following is quoted from Bulletin 1230 of the U. S. Department of Agriculture, entitled "Chimneys and Fireplaces" by A. M. Daniels, Assistant Mechanical Engineer, Division of Agricultural Engineering, Bureau of Public Roads.

> "However, square or oblong forms are far more common than the round, owing to the greater cost of rounded flue construction. Square flues are preferable to oblong so far as efficiency is concerned, but in the larger sizes of house flues the oblong shape is more generally used because it fits to better advantage into the plan of the house. An oblong flue should never have the long side more than 4 inches greater than the short side. A flue 8 inches by 16 inches is bad flue construction for draft purposes. The actual inside dimensions of flue tile are slightly different because of the lack of standardization. In selecting the flue for a furnace or other large heating unit, an 8 inch by 12 inch size should be considered the minimum for a lined or unlined flue, and 12 inches by 12 inches the minimum for a lined or unlined flue whose height is more than 35 feet measured above the grate level. If the chimney is designed for a small unit such as a laundry stove or kitchen range, an 8 inch by 8 inch flue may be used."

It should be noted that the "lack of standardization" mentioned by Mr. Daniels, has been corrected since that bulletin was published and that the figures in the Tables on page 6 are standard for the products of all member companies of the Eastern Clay Products Association.

Sizes of Flues:

The proper cross-sectional area for a flue depends upon the rating or size of the heating appliance, whether it be warm air heater, steam or hot water boiler, stove, range or domestic hot water heater.

Upon the size of the flue is dependent the satisfactory working of any of the above mentioned appliances, and for this reason manufacturers of heating and cooking apparatus have always made it a practice to include in their catalogs, tables of flue and smoke pipe sizes for their particular type of heater.

These tables have, in the past, been based on the many various sizes of flue linings commonly manufactured and in few of these cases were the actual inside effective areas of the flue linings taken into consideration.

In some tables, the sizes were admittedly purely theoretical and bore little relation to the actual sizes of flue linings commercially available. In other words, they left to the architect or heating engineer the figuring of the flue linings which would give the theoretical dimensions stated in the table and the cross-sectional area most suitable for that particular type of heating appliance.

In compiling the data for this publication on flues and flue linings, an investigation was made into the sizes of flues recommended by many manufacturers of heaters and the above facts became apparent.

It was also found that the table of "Minimum Chimney Flue Sizes and Heights" contained in the "Ordinance for the Construction of Chimneys" of the National Board of Fire Underwriters, did not list the sizes of flue linings which would conform to the standards now adopted and which are commercially available in all parts of this country. Furthermore, this table was figured on outside sizes and the actual cross-sectional inside area was not stated, nor was the thickness of the shell of the lining taken into consideration.

A typical example of the confusion which might arise from the use of this table is given here.

An architect has 700 square feet of hot water radiation for which to provide a flue. Referring to the table, he selects an 8" x 12" flue—not realizing that these figures are outside dimensions and that the actual inside effective area of a flue lining would be considerably less.

If the chimney is built unlined, these dimensions are the inside measurements of the masonry according to the note at the head of the table. If he wished to use flue lining, however, he calls for an 8" x 12" flue. This size was formerly manufactured but is no longer available and instead of getting a flue 96 square inches in area, he would get one 8½" x 13" from which must be deducted a thickness of ¾" for the shell on all sides making the inside measurements 7" x 11½" or an area of 80.5 square inches which may be totally insufficient for the type of heater installed.

Realizing these discrepancies and the confusion caused thereby to architects and heating engineers, the cooperation of the American Society of Heating and Ventilating Engineers was sought, in the hope that definite recommendations might be put forth for ratings of heaters in which the sizes of the flue lining would conform to the standard sizes as adopted by the manufacturers of fire clay flue linings.

The American Society of Heating and Ventilating Engineers was at that time preparing its "Code of Minimum Requirements for the Heating and Ventilation of Buildings" which has since been preprinted and distributed to members and other authorities for review and comment. With the cooperation of Sub-Committee VIII on Design of Chimneys and Flues and with the support and cooperation of the National

Board of Fire Underwriters, it was decided to revise the table of flue sizes in the Chimney Ordinance of the N. B. F. U. changing the ratings for apparatus to accommodate them to the inside dimensions of the new standard sizes of flue linings. It was decided to present at the same time columns of data giving the "actual" and "effective" inside flue areas in the light of the most recent investigations and research so as to eliminate as far as possible the necessity for any additional figuring by the designer. This has been accomplished and the table of page 11 presents these recommendations.

Flue Linings 8½" x 13" and over:

Using this table any one can select a flue size and chimney height for any given rating in terms of effective cross sectional area based on inside dimensions of a lined flue and be assured it will be adequate for the heater having that given rating.

In the example previously given the heater rating was 700 square feet. Referring to the table it will be found that a rectangular flue 7" x 11½" inside having an actual net area of 80.5 and an effective area of 70 square inches is required. The chimney should be at least 35 feet high for hot water and 40 feet for direct steam.

It should be noted that in this table the minimum height of the chimney above the grate is given as 35 feet but some authorities claim that any chimney under 40 feet in height will produce an erratic draft depending upon the force or direction of the wind, the amount of moisture in the air or the size and quality of the fuel. The higher the chimney, the less are the effects of these factors.

Flue Linings 8½" x 13" and under:

With regard to the sizes of flues for ranges, stoves, domestic hot water heaters and such appliances, the following will be found to be satisfactory sizes.

Irrespective of whether the fuel used be coal, coke, wood or oil, the *minimum effective area* inside of chimney flue linings for various heating devices should be as follows: for warm air furnaces, or low pressure steam or hot water heating boilers, not less than 70 square inches; for fireplaces, not less than $\frac{1}{10}$ the area of the fireplace opening, but never less than 70 square inches; for stoves, ranges and other forms of room heaters, 39 square inches for rectangular flues or an inside diameter of 6 inches for round flues. In no case should the short cross section dimension of a rectangular flue be less than ⅔ the greater dimension. (Certain flue linings are shown as standards—page 6—with longer sides for special purposes.)

When gas is the fuel used in a heating furnace, boiler or automatic hot water heater, the flue should be the same size and construction as required for stoves and ranges using other fuel. Vent flues where required for other domestic gas burning appliances may be of smaller size but should be not less than 10 square inches.

Flues for Fireplaces:

So important is the matter of the throat and the smoke chamber entrance into the flue for a fireplace, that the subject of flue sizes for this feature of construction is covered under a separate section on Fireplaces. See pages 19 to 23 inclusive.

Flues for Power Plants and Commercial Purposes:

This publication does not attempt to cover the subject of flues larger than those for which flue linings are commercially obtainable. The service of competent engineers should be obtained in this connection and reliable manufacturers of chimney stacks consulted.

CHIMNEYS AND FLUES IN GENERAL

When constructed without flue linings the chimney is almost certain to become a source of danger. The heat from the fire causes the mortar to crumble so that it falls out of place, leaving cracks or holes in the chimney. Being out of view, cracks and holes cannot be detected or known about until a fire shows the defect. It is too late then to make amends. The time to use care is when the chimney is erected. The careful method is to use flue lining in every chimney and to require that the constructors of chimneys shall prove all flues tight before scaffolds are removed or the work is accepted.

Flue lining serves as a fire preventative and gives a flue of uniform dimensions. With flue lining the flue also has a smooth inner surface. Projections of the brickwork and crevices in the mortar joints of the unlined flue, collect soot which not only increases friction in the flue and reduces the net area of the flue, but is also responsible for many chimney fires.

That the effective area of any flue is decreased, if unlined, is given full recognition by the sub-committee on Chimney Design of the Code Committee of the American Society of Heating and Ventilating Engineers. The recommendations of that Committee require, according to the table on page 11 that flues without linings shall be 2 inches greater in each dimension, than if lined. These and the Ordinance of the National Board of Fire Underwriters also require thicker walls when flues are unlined.

The cost of flue lining is only nominal. It is a cheap method of preventing fire, of saving space, masonry and money, of strengthening the chimney and of increasing the efficiency of the flue.

TABLE OF FLUE SIZES AND CHIMNEY HEIGHTS

The following notes are based on an extract from Section VIII of the Preliminary Draft of the Code of Minimum Requirements for the Heating and Ventilation of Buildings, American Society of Heating and Ventilating Engineers. The accompanying table is an extract from the same Section. This Code, December, 1924, has not yet been adopted by the Society

This Table gives the minimum flue sizes allowable for the corresponding sizes of warm-air furnaces, boilers or water heaters. In connection with this Table the following points should be noted:

(a) The ratings given are based on smooth, lined, straight flues. If there is more than one offset or if any single offset is flatter than 60° with the horizontal, the rating should be reduced accordingly.

(b) The dimensions given for the flue linings are the nominal dimensions and the actual inside clear dimensions. For rectangular flues the nominal or commercial dimensions are the outside dimensions; for round flues the nominal diameter is the inside diameter. In computing the area of square and rectangular flues, the corners have been eliminated and the resultant effective area computed from the formula

$$e = \pi \times \left(\frac{B}{2}\right)^2 + B\,(A - B)$$

In this formula (e) equals the effective area and (A) and (B) equals the inside length and width respectively. The effective area is also shown in the table below.

(c) The flue linings listed are standard sizes adopted by the Eastern Clay Products Association.

(d) Flue sizes are based on run-of-mine soft coal but are to be used without reduction for any fuel. The smaller sizes of fuels require excessive draft and when the fuel to be used is screened smaller than the following, each installation requires especial consideration: Anthracite—nut, Bituminous—run-of-mine, Coke—nut.

(e) Steam and water boiler capacities are the rated capacities of the manufacturer.

(f) Flue heights and sizes are based upon an altitude not over 500 feet above sea level. For each one thousand feet above sea level the height of the flue for a given appliance should be increased 10% above the figures in the table and the capacities in the table should be reduced 5%.

(g) The effective area of an unlined round flue shall be based upon a diameter two inches less than the actual diameter. The effective area of an unlined rectangular flue shall be computed from the formula:

$$\text{Effective area in sq. in} = \frac{\pi\,(B-2)^2}{4} + (A-B)\,(B-2)$$

in which (A) and (B) are respectively the long and short inside dimensions in inches.

(h) When a flue for any reason must be built more than 100% in excess of the areas given in the Table, it shall be capped with stone terra cotta, cast-iron or other approved material, having an opening not more than 50% greater than the required area.

(i) When two appliances are to be connected to one flue, the rated capacities of flue of various sizes shall be taken as 60% of those given in the Table. When three appliances are to be connected 'the capacities shall be taken as 40% of those given in the Table. When four appliances are to be connected, the capacities shall be taken as 35% of those given in the Table.

(j) The flue heights and sizes are for ordinary up-draft boilers. For special types of boilers greater heights and area may be required.

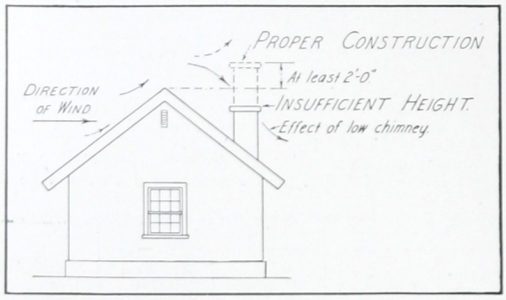
Warm Air Furnace Capacity Sq. In. of Leader Pipe	Steam Boiler Capacity Sq. Ft. of Radiation	Hot Water Heater Capacity Sq. Ft. of Radiation	Rectangular Flue				Round Flue		Height in Ft. from Grate
			Nominal Dimensions of Fire Clay Lining Inches	Actual Inside Dimensions of Fire Clay Lining Inches	Actual Area Square Inches	Effective Area Square Inches	Inside Diameter of Lining Inches	Actual and Effective Area Square Inches	
790	590	973	8½x13	7 x11½	81	70	..	...	35
1,000	690	1,140	.....	.....	...	...	10	79	..
...	900	1,490	13 x13	11¼x11¼	127	99	..	...	..
...	900	1,490	8½x18	6¾x16¼	110	100	..	...	..
...	1,100	1,820	.....	.....	...	...	12	113	40
...	1,700	2,800	13 x18	11¼x16¼	183	156	..	...	..
...	1,940	3,200	.....	.....	...	...	15	177	..
...	2,130	3,520	18 x18	15¾x15¾	248	195	..	...	..
...	2,480	4,090	20 x20	17¼x17¼	298	234	..	...	45
...	3,150	5,200	.....	.....	...	...	18	254	50
...	4,300	7,100	.....	.....	...	...	20	314	..
...	5,000	8,250	24 x24	21 x21	441	346	..	...	55
...	4,600	7,590	.....	20 x24	480	326	..	...	..
...	5,570	9,190	.....	24 x24*	576	452	..	...	60
...	5,580	9,200	.....	.....	...	...	22	380	..
...	6,980	11,500	.....	.....	...	...	24	452	65
...	7,270	12,000	.....	24 x28	672	468	..	...	..
...	8,700	14,400	.....	28 x28	784	531	..	...	..
...	9,380	15,500	.....	.....	...	...	27	573	..
...	10,150	16,750	.....	30 x30	900	616	..	...	..
...	10,470	17,250	.....	28 x32	896	635	..	...	..
...	11,800	19,500	.....	.....	...	...	30	707	70
...	14,700	24,300	.....	.....	...	...	33	855	..
...	17,900	29,500	.....	.....	...	...	36	1,018	..

*Dimensions below are larger than those in which rectangular fire clay flue linings are commercially available and hence are for unlined rectangular flues—requiring thicker walls than when lined. Note that the effective area of an unlined flue is based on the formula in Paragraph (g) above.

CHIMNEY CONSTRUCTION IN DETAIL

The top of the chimney should extend at least 3 feet above flat roofs and 2 feet above the ridge of a peak roof and should not be on the side of the house adjacent to a tree or building higher than itself as these may cause eddies and force air down the chimney.

The drawing shown in Fig. 9 is taken by permission from Farmer's Bulletin No. 1230, U. S. Department of Agriculture, "Chimneys and Fireplaces," and shows clearly the reason for having sufficient height in any

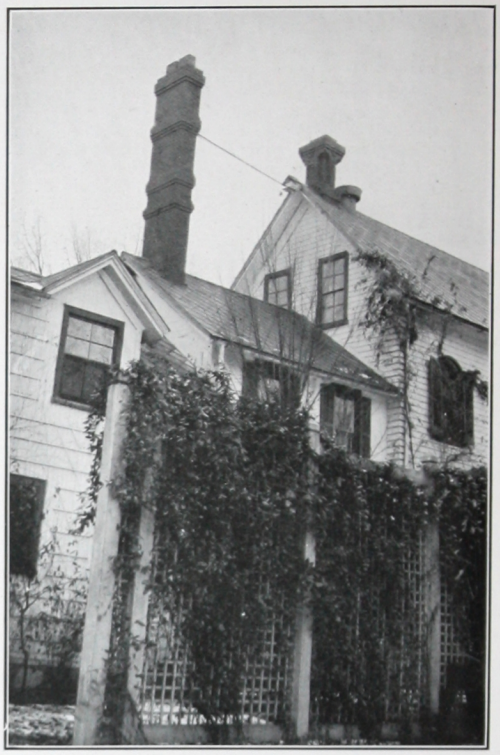


Courtesy of Division of Agricultural Engineering, Bureau of Public Roads, U. S. Department of Agriculture

FIG. 9. TOP OF CHIMNEY SHOULD BE AT LEAST TWO FEET ABOVE THE TOP OF RIDGE IN ORDER THAT THE WIND CURRENTS MAY NOT BE DEFLECTED DOWN THE CHIMNEY.

chimney near a ridge. Fig. 10 from the same publication illustrates the extra trouble and expense which may be incurred by not building the chimney high enough to furnish a good draft when it is first constructed. It is apparent from the picture that the owner of the house made three separate attempts to improve the draft by increasing the height, before securing the result sought for.

It has been found that chimneys constructed entirely within the house are considerably more efficient than those built in the outside walls. This is due to the inside chimney not becoming chilled, holding heat longer and allowing the flues to become hotter, thus giving a better draft. For this reason chimneys built into an outside wall should have thicker walls to retain the heat as much as possible. The two types shown in Fig. 13 illustrate this difference between inside and outside chimneys and serve to indicate the desirability of planning, wherever possible, to have chimneys serving heating apparatus on the inside rather than the outside of a building.



Courtesy of Division of Agricultural Engineering, Bureau of Public Roads, U. S. Department of Agriculture

FIG. 10. SHOWING EXTENSIONS TO THE CHIMNEY REQUIRED IN ORDER THAT IT MIGHT DRAW PROPERLY.

Chimneys should never be constructed with walls less than 8 inches thick, and 12 inches is safer, unless the flues are lined the full length with fire clay flue lining. All adjacent inflammable material should be properly protected from the resultant heat whatever the thickness of the chimney wall.

The majority of building codes recognize this fact and permit chimneys to be built with walls 4 inches and sometimes 8 inches less in thickness for lined flues than those otherwise constructed.

The linings of two flues should not be built side by side although where the joints of the flue linings are carefully staggered or offset, this is often done. (See Fig. 16.) It has previously been considered that when there are more than two flues in a chimney space, at least every third flue should be separated by a "withe" or division wall of brick at least 4 inches thick, bonded into the side walls and the joints of the flue linings should be offset at least 7 inches but both the National Board of Fire Underwriters and the American Society

of Heating and Ventilating Engineers now believe this construction is safe only for cooking and heating stoves and recommend that *every flue intended for a heating furnace or boiler connection, or for a fireplace shall be separated from other flues by a withe.* This construction insures stability, reduces the chances of air leakage between flues and the possible passage of sparks from one flue to the other. See Fig. 17.

Regarding the construction of chimneys and the use of flue linings, the "Recommended Minimum Requirements for Small Dwelling Construction," the report of the Building

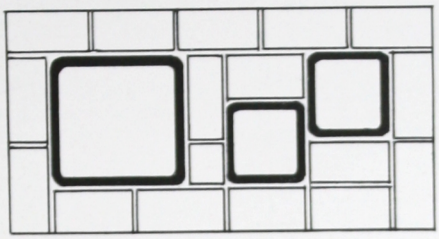


FIG. 11. CHIMNEY BUILT WITH TWO FLUES NOT DIVIDED BY "WITHE" BUT THIRD FLUE SEPARATED BY FOUR INCHES BRICK DIVISION WALL.

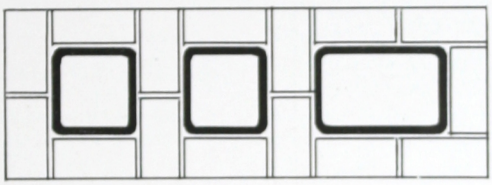
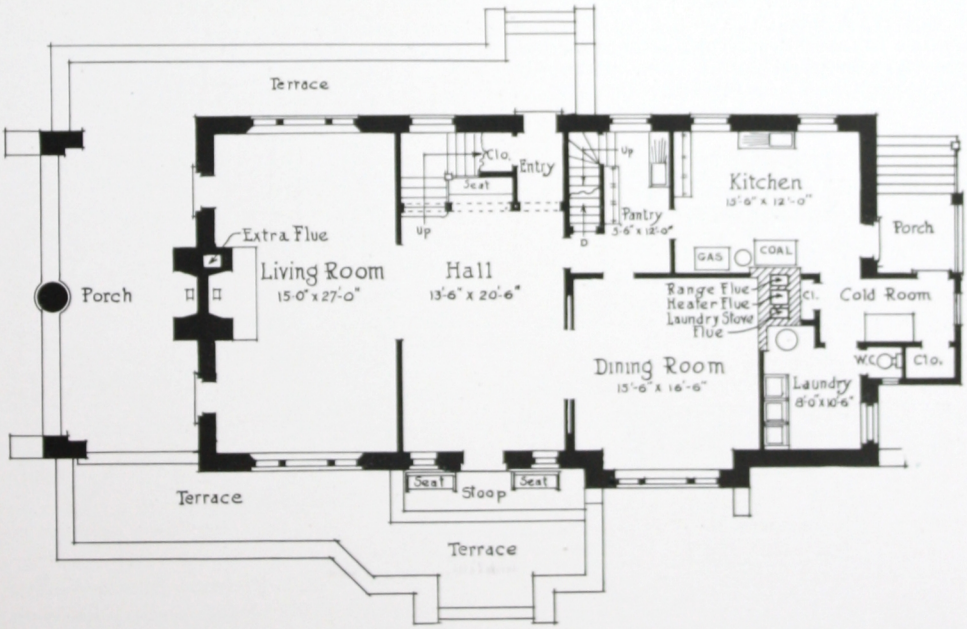


FIG. 12. EACH FLUE SEPARATED FROM THE OTHERS BY "WITHE". THIS ARRANGEMENT PREFERABLE TO THAT SHOWN IN FIG. 11.

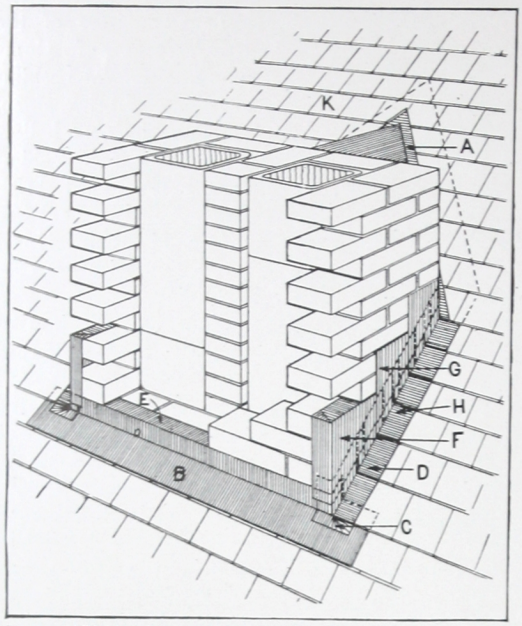
Code Committee of the Department of Commerce, says, "All chimneys built of brick, stone, concrete block, or hollow building tile, except chimneys having solid brick walls 8 inches or more thick, shall be lined throughout with fire clay flue lining."

Since the drawings of chimney construction in the "Ordinance" and other publications of the National Board of Fire Underwriters illustrate brick chimneys, a specification for brick chimneys with fire clay flue linings has been prepared and will be found on pages 27 and 28. If, however, it is desired to construct the



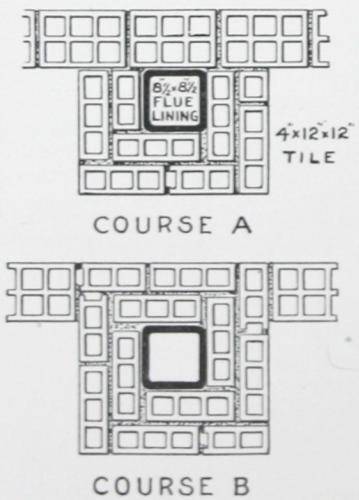
First Floor Plan

FIG. 13. PLAN SHOWING BOTH INSIDE AND OUTSIDE CHIMNEYS.



Courtesy of Division of Agricultural Engineering, Bureau of Public Roads, U. S. Department of Agriculture

FIG. 14. CHIMNEY AND ROOF CONNECTION. SHEET METAL A SHOULD HAVE ROOFING UNITS K OVER IT AT LEAST FOUR INCHES. APRON B BENT AS AT E WITH BASE FLASHINGS C, D, AND H AND CAP FLASHINGS F AND G, LAPPING OVER THE BASE FLASHINGS PROVIDE WATERTIGHT CONSTRUCTION. WHEN THE CHIMNEY CONTAINS TWO FLUES THE JOINTS SHOULD BE SEPARATED AS SHOWN.



From the Report of the Building Code Committee, U. S. Department of Commerce

FIG. 15. APPROVED HOLLOW-TILE CONSTRUCTION FOR CHIMNEYS.

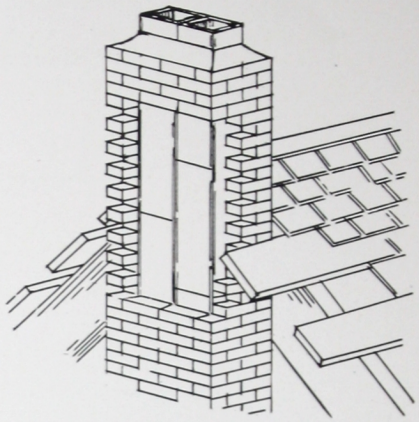


FIG. 16. CHIMNEYS ARE FREQUENTLY BUILT WITH STACKS OF FLUE LINING TOGETHER. JOINTS SHOULD BE OFFSET AT LEAST SEVEN INCHES. THE METHOD SHOWN IN FIG. 17 BELOW IS BETTER.

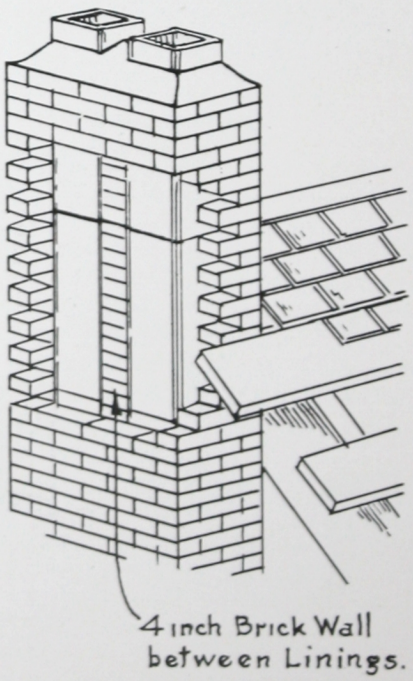


FIG. 17. PROPER METHOD OF BUILDING CHIMNEY WITH TWO FLUES, BOTH LINED WITH FLUE LINING AND SEPARATED BY A "WITHE" OR DIVISION WALL.

chimney of some other material than brick, the specification may be revised accordingly.

The following quotations from the "Recommended Minimum Requirements for Small Dwelling Construction" describe good practice when chimneys are constructed of other materials than brick.

> "Concrete for chimneys cast in place shall flow readily, be well rodded, and shall be reinforced vertically and horizontally. The walls shall be not less than 3¾ inches thick and shall be lined with fire-clay flue lining, or the linings may be omitted, provided the walls of the chimney be not less than 6 inches thick.
>
> "NOTE.—Pure quartz gravel or other highly siliceous gravel concretes are not adapted to withstand rapid rises of temperature and it is therefore recommended that they should not be used for chimneys where subject to direct attack of heat.
>
> "Concrete blocks used in chimney construction shall be not less than 3¾ inches thick, and blocks inclosing more than one flue shall have suitable reinforcement completely encircling the blocks and well imbedded in them.
>
> "NOTE.—The reinforcement required in concrete chimneys cast as a unit, or when built of large blocks inclosing more than one flue, is to resist stresses due to temperature variations or unequal settlement of foundations.
>
> "Stone chimneys unless built of sawed or dressed stone in courses, properly bonded at corners and tied with metal anchors, shall have walls at least 8 inches thick."

In some sections of the country, hollow building tile are used for the construction of chimneys forming parts of walls. When such are used, they should form a double wall never less than 8 inches thick lined with fire clay flue lining, and the joints of the flue lining should be carefully staggered with those of the inside 4 inches thick hollow tile. The outside walls of the chimney should be securely bonded into the walls of the building. No chimney should be corbeled from a hollow tile wall. The method of constructing chimneys of hollow building tile, as recommended in the Report of the Building Code Committee of the U. S. Department of Commerce is shown in Fig. 15.

It is important that flues be constructed as straight as possible as each offset provides additional friction and so reduces the efficiency of the draft. Soot may also lodge in bends or offsets and form dangerous fire hazards. Where it is necessary to change the angle of the flue, the change should be gradual and the slope should not be flatter than 30 degrees. Each piece of flue lining used on an offset should be carefully cut and jointed. If a lining is improperly fitted the flue area may be reduced to such a degree as to destroy an otherwise excellent draft.

All joints in both the brickwork and the flue lining should be carefully filled with mortar and any space between the lining and brick should be slushed in with mortar as the chimney is built up. As stated in the Specification on pages 27 and 28 the flue should invariably be set in place and the brickwork built around it—never should the walls be built first and the lining dropped in as has been so frequently done.

To prevent the base of the flue being clogged up and to catch mortar droppings, a bag of shavings fitting the flue tightly may be drawn up as the flue is built by a rope attached to the top of the bag.

Supports for Chimneys:

Every chimney should be supported on a proper foundation and no weight should be carried by a part of the building other than the walls when properly corbeled. The foundation and footings should be carefully proportioned to the weight of the chimney and the safe bearing capacity of the soil. In general it is sufficient to make the footing 6 inches wider all around than the chimney and 8 inches to 12 inches deep. In all cases the footing should start well below the frost line for the locality in which the building is erected.

"Dwelling Houses" a code of suggestions for the construction of residences and their protection against fire, recommended by the National Board of Fire Underwriters, states regarding the support of chimneys:

> "A chimney shall never rest upon or be carried by wooden floors, beams, or brackets, or hung from wooden rafters. In frame buildings chimneys shall always be built from the ground up, or rest on basement walls.
>
> "NOTE.—Wooden construction is certain to shrink, and beams carrying heavy loads always deflect in time even though they may support the load without sign of distress when first applied. Settlement is sure to occur, and such movement not only injures the wall and ceilings of the house, but is very liable to crack the chimney and render it dangerous. Such chimneys are always several feet in height above the roof, thus offering considerable surface exposure, and owing to their unstable support they will sway in a heavy wind. This also tends to produce open joints at the roof line, which is a most hazardous place for sparks to issue as they come directly in contact with the woodwork.
>
> "Do not support chimneys on iron brackets or stirrups attached to wooden construction however carefully devised. This practice is not uncommon, but is hazardous for reasons explained above. Furthermore, a small fire around thebase, from any cause, may drop the chimney and form a draft for rapid spread of fire.
>
> "NOTE.—It is well known that steel begins to lose its strength at about 500 degrees Fahr., and at 1,000 degrees Fahr. approximately 50 to 70 per cent. of its strength is gone. Such temperatures are produced in an ordinary fire, and if maintained even for a short time are almost sure to produce collapse of exposed steel structural members."

Mortar for Chimney Construction:

The "Ordinance for the Construction of Chimneys" recommended by the National Board of Fire Underwriters, specifies that:

> "All mortar used in chimney construction, except as specified for fire brick . . . . . shall be cement mortar proportioned as follows: Two bags of Portland cement, not less than 188 pounds, and one bag of dry hydrated lime, 50 pounds, thoroughly mixed dry. To this mixture shall be added three times its volume of clean, sharp sand with sufficient water to produce proper consistency. When dry hydrated lime is not available 1 cubic foot of completely slaked lime putty may be substituted for 50 pounds of dry hydrate. In case of such substitution, the mixing of lime and cement shall be very thorough. Dry hydrate should always be used in preference to lime putty."

Openings into the Chimney:

Many fires from chimneys are caused by permitting more than one opening into each flue. This should never be permitted as sparks may enter the flue at one opening and pass out at the other. No range, stove, fireplace or ventilating register should be connected with the flue built for the heating or cooking apparatus, although this is sometimes done in case of ventilating the hood of a cooking range. If it is necessary to use a flue in one room which has an opening into another room, the latter should be carefully and tightly closed with incombustible material before a fire is started.

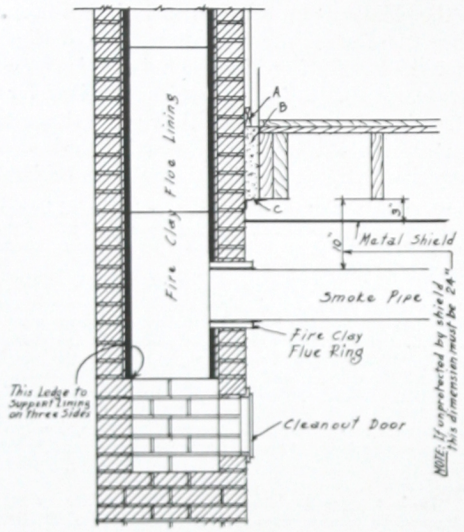


FIG. 18. SHOWING LEDGE TO SUPPORT FLUE LINING, SOOT POCKET AND CLEANOUT DOOR. ALSO PROTECTION OF JOISTS ABOVE SMOKE PIPE OF LARGE COOKING RANGES, HOT AIR FURNACES, STEAM AND HOT WATER BOILERS. A=PIECES OF ASBESTOS BOARD BACK OF WOOD FURRING. B=INCOMBUSTIBLE FILLING. C=STRIP OF SHEET METAL OR METAL LATH.

Not only is there risk of fire from two openings, but this is one of the main causes of unsatisfactory operation. When two stoves, one on the first floor and one on the second are connected to the same flue, it will be found that when the fire in the upper stove is hotter than in the lower, the lower will have practically no draft.

Provision should be made for a soot pocket with a cleanout door at the bottom of each flue, other than for a fireplace. The top of the door should be placed as close as possible to, and not more than one foot from, the smoke entrance at the base of the chimney and should fit snugly to prevent the admission of air. It has frequently been the custom to extend soot pockets in basements, and elsewhere, to the floor with a cleanout door at that level but the best authorities now advise against the construction of a flue below the smoke

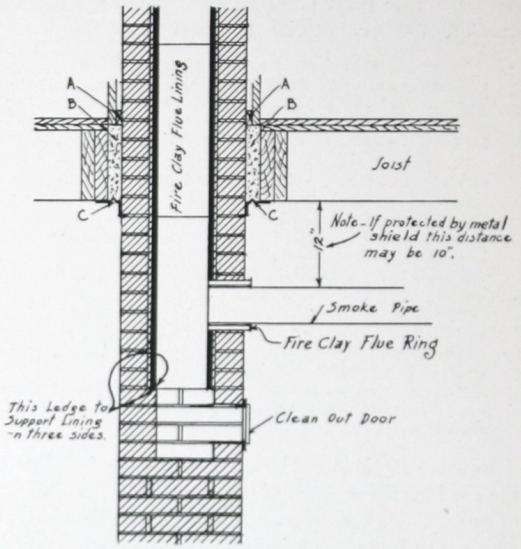
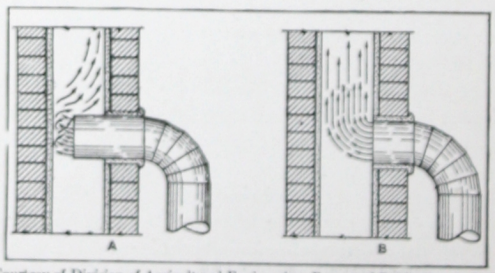


FIG. 19. PROTECTION OF JOISTS ABOVE SMOKE PIPE OF STOVES, SMALL DOMESTIC HOT WATER HEATERS AND SMALL COOKING RANGES. THIS REPRESENTS IDEAL CONSTRUCTION. IF FLUE LININGS ARE BUILT TOGETHER WITHOUT "WITHE" THE LEDGE OF BRICK SHOULD BE OMITTED AND THE LINING CARRIED TO THE BOTTOM OF THE POCKET TO PROVIDE ADEQUATE SUPPORT. A=PIECES OF ASBESTOS BOARD BACK OF WOOD FURRING. B=INCOMBUSTIBLE FILLING. C=STRIP OF SHEET METAL OR METAL LATH.

pipe opening any larger than is required for placing the cleanout door, as the cold air below the pipe hole may chill the entire column of smoke in the chimney and impede the ascent of the smoke. See Figs. 18 and 19.



Courtesy of Division of Agricultural Engineering, Bureau of Public Roads, U. S. Department of Agriculture

FIG. 20. A. WRONG CONNECTION, PRODUCING INTERFERENCE AND A POOR DRAFT. B. CORRECT CONSTRUCTION, PRODUCING A GOOD DRAFT BY PROVIDING A FREE PASSAGE FOR THE SMOKE.

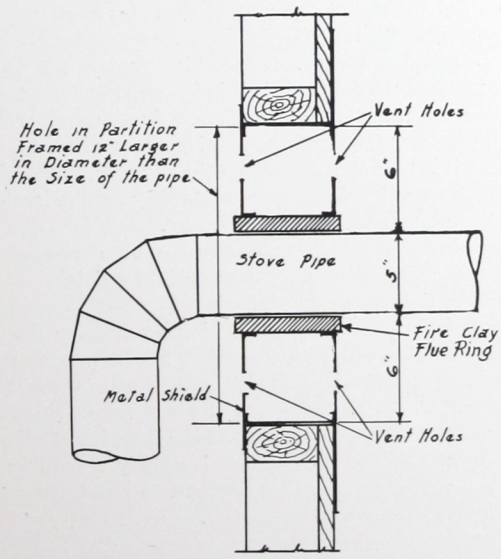
Smokepipe and Chimney Connections:

It is most important that proper care be taken in the setting of smoke pipes connecting heating apparatus to the chimney for at this point is the source of many fires.

In fitting the smokepipe into the chimney, no opening should be left around it but it should be made absolutely air-tight by a close fitting "thimble" of fire clay designated as a Flue Ring (see page 24). If there is a space between the pipe and the ring this should be carefully sealed with boiler-putty or fireproof cement.

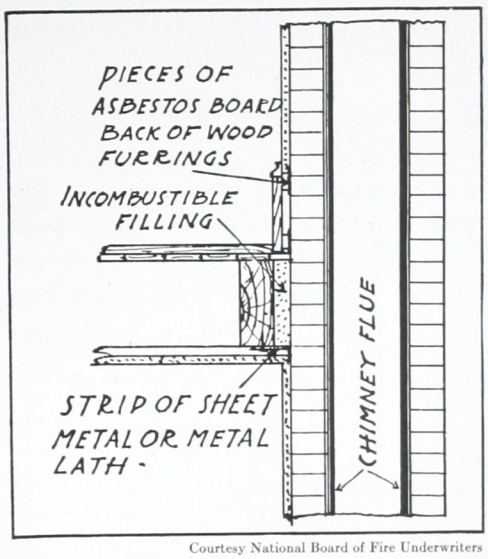
The smokepipe from stoves should be kept at least 12 inches below the ceiling joists above. For hot-air furnaces or similar smokepipes the distance below the joists above should be at least 24 inches unless the joists are protected with a metal shield having an air space of at least 3 inches all around. In this case the pipe may be placed within 10 inches of the joists. The location of the smokepipe should be determined at the time the chimney is built to permit proper location of the thimble or opening into the flue in accordance with these recommendations as to height, or clearance, which are those of the Committee on Building Construction of the National Fire Protection Association (1924 Report).

The proper construction is shown in Fig. 20. The pipe should not extend into the chimney as shown in "A" or be run in vertically as is the custom in some parts of the country. Such practice reduces the flue area and may result in a poor draft just as would be caused by closing the damper in the smokepipe but, even more important, such an extension furnishes a shelf on which soot may accumulate and in case of a flue fire the sparks will ignite the soot causing a dangerous hazard.



Revised from standard of National Board of Fire Underwriters

FIG. 21. SECTION VIEW OF PROTECTION AROUND STOVE-PIPE PASSING THROUGH WOODEN PARTITION.



Courtesy National Board of Fire Underwriters

FIG. 22. DETAIL SHOWING SUPPORT FOR FIRE-STOPPING AROUND CHIMNEY, AND PROTECTION FOR WOODWORK PLACED NEXT TO PLASTER ON CHIMNEY BRICKWORK.

If the walls are furred, no wood should be closer than 12 inches to any part of the smoke pipe. The space between the pipe and the wood furring should be covered with metal lath and plaster. A smokepipe should not be closer than 18 inches to woodwork unless the upper half nearest the woodwork is protected by 1 inch or more of fireproof covering or a metal casing 2 inches from the upper half of the pipe. Even with such protection the pipe should not be closer than 9 inches to the wood.

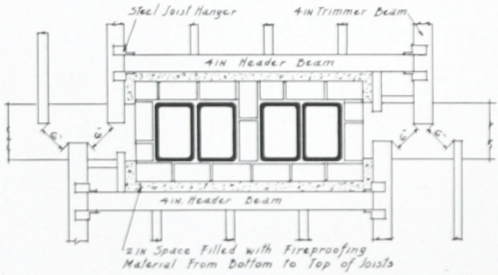
Sometimes it becomes necessary to carry a smoke pipe through a wood partition but this should never be done if it can be avoided. When this is done, however, the woodwork should be protected from the pipe by at least 4 inches of brickwork or other incombustible material or by cutting an opening in the partition and inserting a galvanized iron double walled ventilated thimble having a diameter not less than 12 inches

larger than the pipe. A fire clay flue ring should be placed on the smokepipe as shown. This protection is illustrated in Fig. 21. Smokepipes should never pass through floors, or through closets or other concealed spaces for there is always the danger of clothes or furniture being placed too near the pipe when cold and later forgotten when a fire is started and the pipe becomes hot.

Flue holes when not in use, should be closed tightly with metal covers. These covers should never be papered if there is another flue opening into the same chimney, for the metal may become hot enough to scorch or set fire to the paper.

Insulation of Woodwork from Chimneys:

It would hardly seem necessary to state that all joists, furring, lathing and other woodwork should be well insulated from the chimney construction, but this is one of the most frequent causes of fire.


Steel Joist Hanger
4IN Trimmer Beam
4IN Header Beam
4IN Header Beam
2IN Space Filled with Fireproofing Material From Bottom to Top of Joists

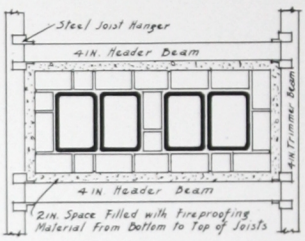
Redrawn from standard of National Board of Fire Underwriters

FIG. 23. FLOOR FRAMING AROUND CHIMNEY IN PARTY WALL, TO SECURE PROPER SPACE BETWEEN ENDS OF JOISTS.

A space of at least 2 inches should be left between the outside face of the chimney and all wooden beams or joists and this space should be filled with an incombustible material such as loose cinders, loose mortar refuse, or gypsum block. Solid material such as brickwork, mortar, or solid concrete should not be used. The loose material should be supported by strips of sheet metal or metal lath set into the brickwork and nailed to the wooden beams, as shown in Figs. 18, 19 and 22, so as to form a buckled flexible joint.

Wooden studding, furring, lathing or plugging should never be placed against a chimney. Such construction should be set away from the chimney as shown in Figs. 23 and 24, or the plastering should be directly on the masonry or on metal lath or incombustible furring material.

For protection of woodwork around fireplaces see section on "Fireplace Construction."


Steel Joist Hanger
4IN. Header Beam
4IN Trimmer Beam
4IN. Header Beam
2IN. Space Filled with Fireproofing Material From Bottom to Top of Joists

Redrawn from standard of National Board of Fire Underwriters

FIG. 24. ORDINARY FLOOR FRAMING AROUND CHIMNEY. ALL TIMBERS TWO INCHES CLEAR OF BRICKWORK AND SPACE FILLED WITH FIREPROOFING MATERIAL.

Smoke Test for Leakage:

Before apparatus is connected with any flue and before the scaffolding around any chimney is removed, but after the mortar has hardened, a smoke test should be applied. One method for conducting this test is to build a smudge fire of paper, straw, wood or tar paper at the base of the flue and when a dense column of smoke is ascending, tightly block the outlet by placing a wet blanket over it. If the chimney does not draw well at first the column of air in it should be forced out either by firing a Roman Candle in the flue or by filling a bag with shavings, pouring oil over it and then when it is blazing pulling it up the chimney by a chain.

If there are leaks at any points they can be located at once by the appearance of smoke. Bad leaks due to carelessness in building masonry are often revealed in this manner. Such leaks may be into adjoining flues or directly through the walls or between the walls and the lining. A chimney which shows a leakage should never be accepted until the defect has been remedied. Such a test should be made in the presence of the mason contractor, the heating contractor and the architect or owner or his representative. As the stopping of a leak after the chimney is completed is usually very difficult it will well repay the time required to watch the construction closely as it progresses.

FIREPLACE CONSTRUCTION

The fireplace has always been the center of the home and a cheery fire on the hearth has ever been the symbol of welcome. For some years after the advent of modern heating appliances, the fireplace was considered unnecessary as an adjunct in the home and few were installed. Today, however, it is almost safe to say that the real home is built around the fireplace and few houses are thought too small to contain at least one.

As constructed today but comparatively few fireplaces are efficient or economical and many form a fire hazard of no little importance. In order that the open fireplace may act as an auxiliary to the heating plant and to eliminate danger from fire, it should be properly and carefully constructed.

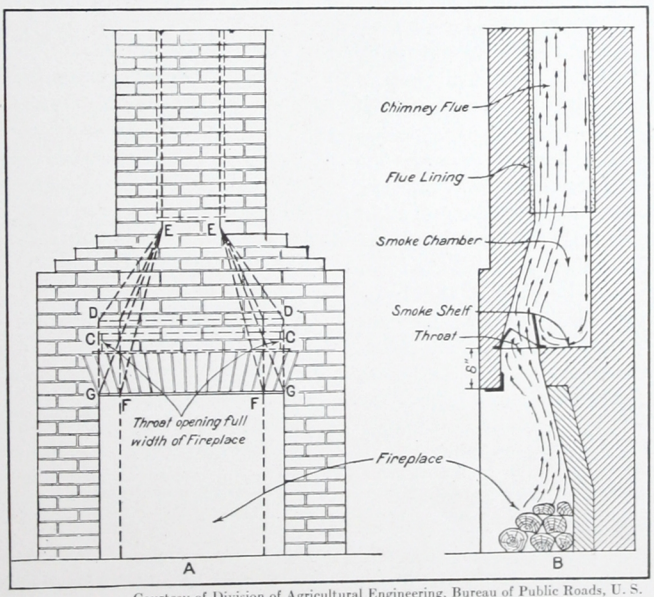
Several points should be taken into consideration, among them the following, the first five of which are quoted from Bulletin No. 1230 of the Department of Agriculture: (1) The flue should have a proper area for the fireplace opening; (2) The throat should be properly proportioned and located; (3) A smoke shelf and chamber should be provided; (4) The chimney should be carried high enough to avoid interference with the draft; (5) The shape of the fireplace should be such as to direct the heat into the room; (6) The location, proportions and surroundings should make not only for warmth but for cheerful attractiveness.

Proportioning the Flue:

The cross-sectional area of the flue bears a direct relation to the area of the fireplace opening. A good proportion for flues for fireplaces in which wood or bituminous coal is to be burned is to make the *effective* sectional area of the flue one-tenth the area of the fireplace opening if the flue is rectangular, and one-twelfth if the flue is circular. Thus, if a fireplace opening is 30 inches wide and 30 inches high it will have an area of 900 square inches and the effective flue area for a rectangular flue should be 90 square inches. This would require a 13″ x 13″ or an 8½″ x 18″ rectangular flue lining. These figures are outside dimensions and allowance has been made for the thickness of the shell of the lining and for eliminating the corners (See Pg. 11[b]).

For a circular flue lining the area should be one-twelfth of 900 or 75 square inches. The nearest standard size of lining is 10 inches in diameter which has an area of 78.54 square inches. If anthracite coal is to be burned the flue area may be made one-fifteenth the area of the fireplace opening for a rectangular flue and one-eighteenth for the circular form, but it is of course, always safest to so design and construct a flue that it will amply provide for the use of any kind of fuel.

A flue should not be contracted at the chimney top as this nullifies the large opening below; if it is necessary to change the direction of a flue, the full area should be preserved and the change made as gradually as possible.



Courtesy of Division of Agricultural Engineering, Bureau of Public Roads, U. S. Department of Agriculture

FIG. 25. A. TOP OF THROAT DAMPER IS AT DD, SMOKE SHELF AT CC. SIDE WALL SHOULD NOT BE DRAWN IN UNTIL THE HEIGHT DD IS PASSED. THIS ASSURES FULL AREA. IF THE DRAWING IN IS DONE AS INDICATED BY LINES EF AND EG, THE WIDTH OF THE THROAT BECOMES LESS THAN THE WIDTH OF THE OPENING AND CAUSES THE AIR CURRENTS TO PILE UP IN THE CORNERS OF THE THROAT, RESULTING FREQUENTLY IN A SMOKY FIREPLACE. **B.** SHOWS ONE METHOD OF PLACING THROAT DAMPER WHICH IS MORE DIFFICULT OF OPERATION THAN THAT INDICATED IN FIG. 34. LOGS SHOULD BE ELEVATED ABOVE HEARTH.

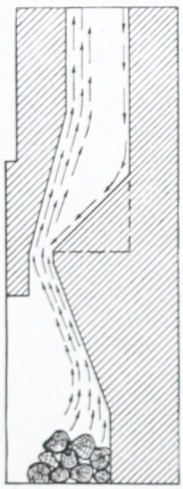
The Throat Construction

The correct construction of the throat of a fire place flue contributes much to the efficiency of a chimney. The throat is the narrow opening between

the fireplace and the smoke chamber, as shown in Fig. 25. The draft depends not so much upon the largeness of the flue as upon its proper proportioning to the fireplace and the throat. Therefore, a flue much over size but brought straight down to the fireplace without a longitudinal narrowing at the throat would result in a poor draft and waste of heat.

The arrows indicate the direction of the upward currents of warm air which pass through the throat at the front and into the smoke chamber and flue on the inside. This rapid upward passage of air causes a down draft on the opposite side as indicated by the descending arrows. This down current may be of such force as to drive the smoke into the room if there is no throat.

A few directions for the proper construction of a throat will do away with much of this trouble if they are followed closely. The area of the throat should be not less than that of the flue and its length at the bottom should be equal to the width of the fireplace opening. The sides should be vertical until the throat is passed and above the throat the sides should be drawn in gradually until the desired flue area is secured. The throat should be not more than 4 or 5 inches wide and located as near the front of the fireplace as possible. In cases where the damper is installed this will determine the width of the opening as the cover regulates the width of the throat proper. Two different methods of throat construction are shown in Figures 25 and 34. In Figure 25 the throat is set 8″ above the lintel. In Figure 34 the damper forms the lintel.



Courtesy of Division of Agricultural Engineering, Bureau of Public Roads, U. S. Department of Agriculture

FIG. 26. THIS CONSTRUCTION WITHOUT A THROAT DAMPER OR SMOKE SHELF IS BAD. IT DIRECTS THE DOWN DRAFT SO THAT IT MEETS THE UP DRAFT ALMOST AT THE THROAT.

Smoke Shelf and Chamber:

The smoke shelf is formed as shown in Figs. 25 and 34 by setting back the brickwork at the top of the throat to a line of the flue wall. The depth will depend upon the depth of the fireplace but should be not less than 4 inches. The purpose of this shelf is to change the direction of the down draft so that the hot gases will strike it at a right angle rather than head on.

The smoke chamber is the space from the top of the throat to the bottom of the flue proper and between the side walls. This space being large at the bottom forms a reservoir which will hold the smoke in case the draft is cut off by a gust of wind. The walls should be drawn inward 1 foot for each 18 inches of rise to reduce friction and if made as smooth as possible less interference with the movement of the air currents will result.

Shape of the Fireplace:

The depth of a fireplace should not be too great for the width and 18 inches to 22 inches will be found satisfactory for all small fireplaces. The sides should be splayed, as straight sides do not radiate much heat into the room. The back should slope forward starting about four bricks above the hearth level. Unless a hood is

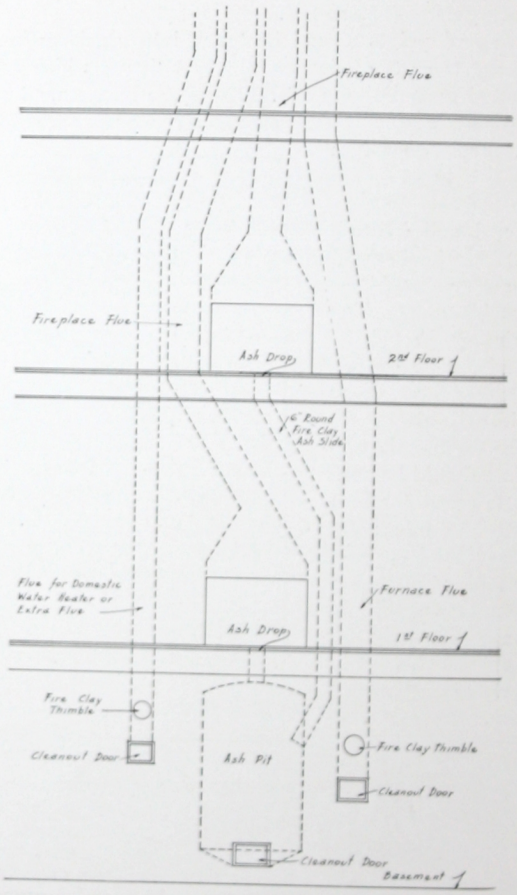


FIG. 27. ILLUSTRATING ARRANGEMENT OF FLUES FOR TWO FIREPLACES, FURNACE AND DOMESTIC WATER HEATER OR EXTRA FLUE. ALSO SHOWS ASH SLIDE FROM FIREPLACE ON SECOND FLOOR.

used, the height of the opening should be less than the width or there is liable to be smoke trouble.

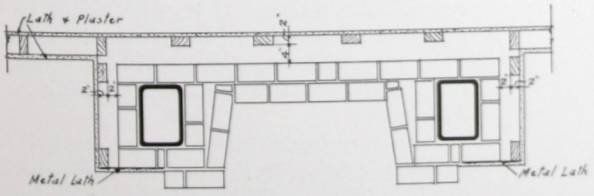
The hearth should extend 16 inches to 20 inches in front of the fireplace to protect the floor from sparks and embers. The back hearth should be provided with an ash drop. This consists of a cast-iron metal frame usually with a pivoted cover through which ashes and refuse can be brushed into an ash pit below.

When one fireplace occurs over another, an ash slide may be provided for the upper one by building in a 6-inch fire clay flue lining connected with the ash drop and basement pit. The ash slide should be built as straight as possible as sharp bends will tend to become blocked up and prove more of a menace than help. The ash pit should be of perfectly tight masonry and fitted with a tightly fitting cleanout door, and have a cemented floor steeply sloped from back and sides toward the cleanout. See Figs. 27 and 34.

The Throat Damper:

A throat damper should be a part of every fireplace as it furnishes a means of regulating the fire and preventing considerable loss of heat. There are a number of patterns on the market and they usually are alike in that they consist of a cast iron frame with a hinged lid which varies the width of the throat opening from nothing to six inches.

Closing the damper in summer prevents the entrance of insects by way of the chimney and in winter, prevents the fireplace from interfering with the even heating by modern systems. A fireplace not closed will often pull air from distant parts of the house and keep the heater running beyond normal necessity because the warmed air is escaping. For this reason the guarantees of heating contractors usually require throat dampers in all fireplaces.

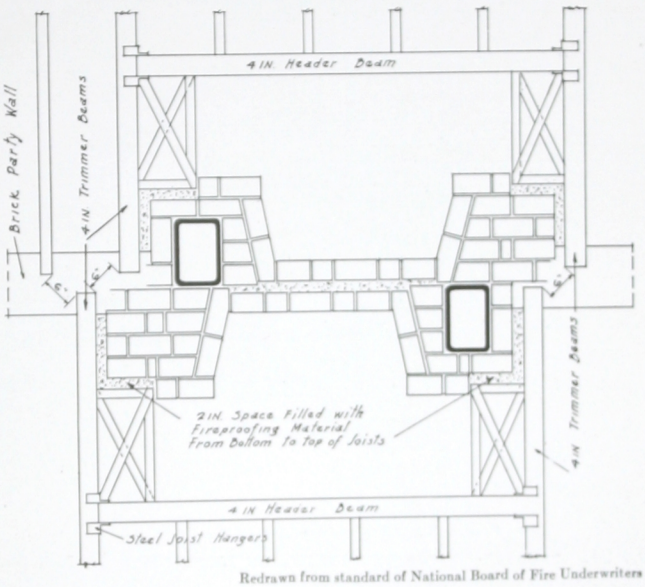


Redrawn from standard of National Board of Fire Underwriters

FIG. 28. STUD PARTITION ACROSS BACK OF A FIREPLACE AND AROUND THE ENDS OF THE CHIMNEY BREAST, SHOWING PROPER ARRANGEMENT OF STUDS.

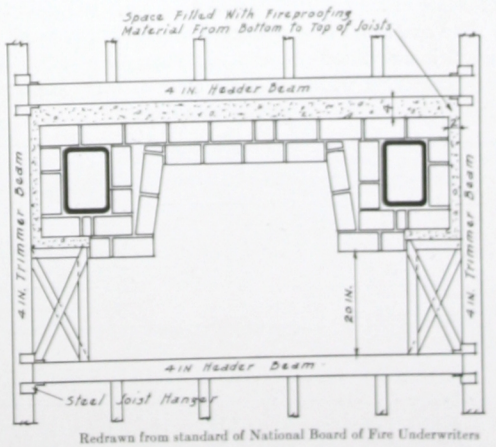
Protection of Woodwork around Fireplaces:

The construction of all woodwork adjacent to a fireplace, whether for framing, mantels or shelves should be carefully planned to avoid fire hazards.


4 IN. Header Beam
Brick Party Wall
4 IN Trimmer Beams
2 IN. Space Filled with Fireproofing Material From Bottom to Top of Joists
4 IN Trimmer Beams
4 IN Header Beam
Steel Joist Hangers

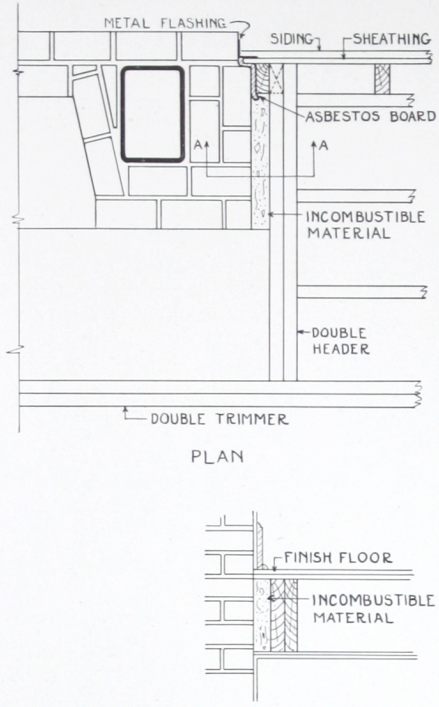
Redrawn from standard of National Board of Fire Underwriters

FIG. 29. METHOD OF BUILDING TWO FIREPLACES BACK-TO-BACK IN A BRICK PARTY WALL TO SECURE PROPER SPACING BETWEEN ENDS OF FLOOR JOISTS.


Space Filled With Fireproofing Material From Bottom to Top of Joists
4 IN. Header Beam
4 IN. Trimmer Beam
4 IN. Trimmer Beam
20 IN.
4 IN Header Beam
Steel Joist Hanger

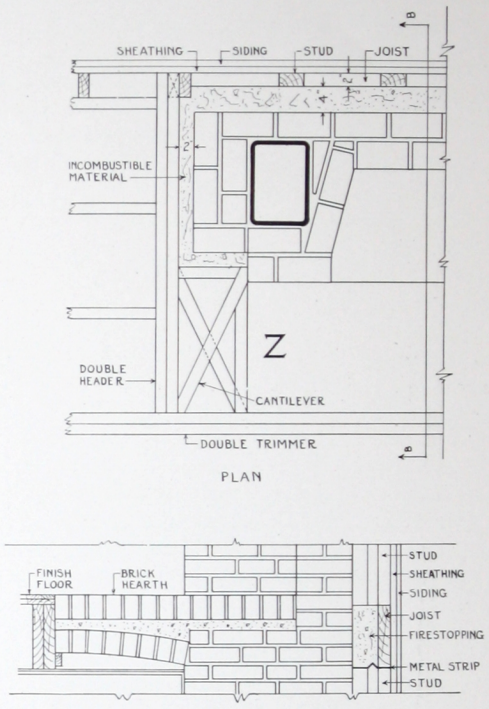
Redrawn from standard of National Board of Fire Underwriters

FIG. 30. FLOOR FRAMING AROUND A SINGLE FIREPLACE. NOTE FILLING BETWEEN FRAMING AND BRICKWORK, WHICH SERVES BOTH AS INSULATOR AND FIRE-STOP.



Courtesy National Lumber Manufacturers Association

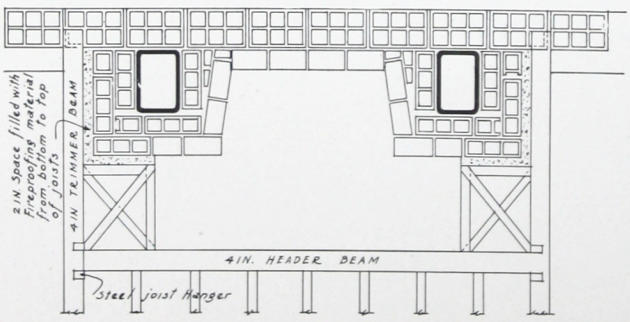
FIG. 31. PROTECTION AROUND FIREPLACE EXTENDING THROUGH OUTSIDE WALL.



Courtesy National Lumber Manufacturers Association

FIG. 33. PROTECTION AROUND FIREPLACE IN OUTSIDE FRAME WALL.

The header beam supporting the trimmer arch of the fireplace should be at least 20 inches from the chimney breast. As previously mentioned, the hearth itself should be of incombustible materials such as brick, tile or slate and should be supported on an arch of brick at least 3 inches thick as shown in Figs. 33 and 34. All wood centering which may be used to carry the arch during construction should be removed.


2 IN Space filled with fireproofing material from bottom to top of joists
4 IN TRIMMER BEAM
4 IN. HEADER BEAM
Steel joist Hanger

Revised from Report of Building Code Committee, U. S. Department of Commerce

FIG. 32. APPROVED HOLLOW TILE CONSTRUCTION FOR FIREPLACES.

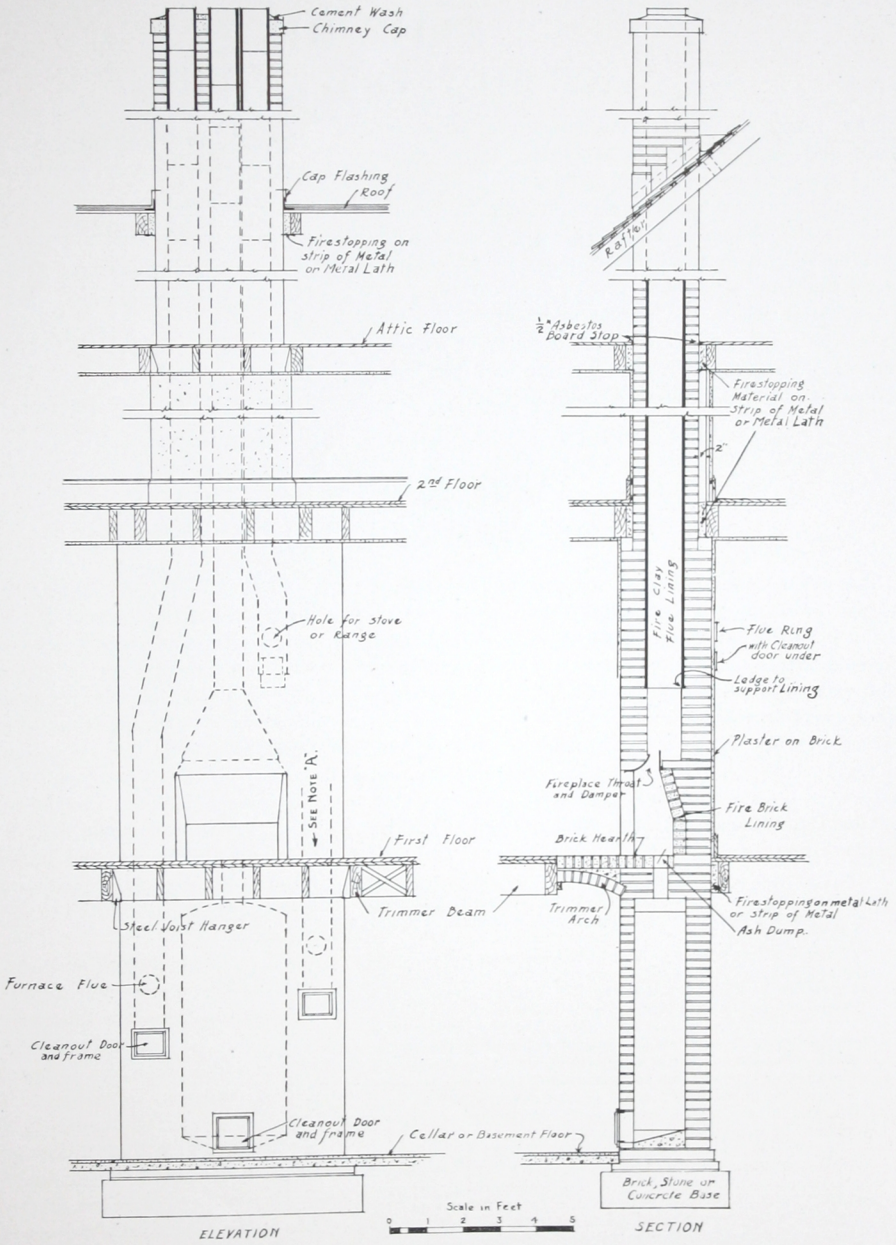
The most usual method in residence construction is to expose the back of the fireplace and its chimney on the outside of the building. This method is illustrated in Figs. 13, 31 and 32. There should be not less than 8 inches of masonry between the wood and the flue lining. In frame houses, an offset should be provided in the masonry so that the sheathing may lap over and make a right angled joint which is filled with asbestos board and flashed to make it fire safe and to prevent the entrance of weather into the building.

When the fireplace does not extend through the wall the studding at its back should be separated not less than 4 inches from its back wall. Proper fire stopping should be provided in this space at each floor level as shown in Fig. 33.

In party walls a fireplace is sometimes built on one side only. In this case the joists back of the fireplace should be carried on a double header kept at least 4 inches away from the wall and the space between should be filled with loose incombustible material as shown in Fig. 30.

When fireplaces are built back to back in a party wall, neither flue should project beyond the center line of the party wall and a slight offset should be made to permit the placing of the joists with the proper separation between ends as shown in Fig. 29.

Many times it is desirable to have the hearth of less width than the fireplace breast. This is often true when it is desired to use an ornamental mantel piece around the opening and plaster up to that point. The floor can then be carried on a cantilever support as shown at "Z" in Fig. 33.



Revised from standard of National Board of Fire Underwriters

FIG. 34. ELEVATION AND SECTION OF AN INTERIOR INDEPENDENT CHIMNEY SHOWING RECOMMENDED CONSTRUCTION. NOTE A.—IT IS RECOMMENDED THAT AN EXTRA FLUE ALWAYS BE BUILT IN A CHIMNEY BREAST. THE MASONRY DISPLACED FROM THE CHIMNEY BREAST WILL PRACTICALLY PAY FOR THE COST OF THE LINING AND THE ONLY ADDITIONAL COST WILL BE FOR THE LINING AND BRICKWORK FOR THREE ADDITIONAL 4" WALLS SURROUNDING IT IN THE CHIMNEY ITSELF. SUCH A FLUE WILL BE FOUND INVALUABLE FOR DOMESTIC HOT WATER HEATER, LAUNDRY STOVE OR OTHER APPLIANCES NOT PERHAPS ORIGINALLY CONTEMPLATED.

FLUE RINGS
(OR STOVEPIPE "THIMBLES")

Flue rings, or thimbles, as sometimes called, are made and burned in the same manner as flue lining. They are used to make the opening which connects stove-pipe, furnace pipe or cleanout hole to the flue through the chimney. They are superior to a round opening shaped in the brick chimney or to ordinary metal thimbles, which may rust or disintegrate.

The joint where the smoke pipe enters the ring should be made airtight with boiler putty or asbestos cement. When possible, the flue ring and flue lining should be carefully pointed to make airtight.

Standard Dimensions of Flue Rings

Inside Diameter, Inches	Length, Inches	Minimum Thickness, Inches
6	4½, 6, 9, 12,	5/8
7	4½, 6, 9, 12,	11/16
8	4½, 6, 9, 12,	3/4
10	4½, 6, 9, 12,	7/8
12	4½, 6, 9, 12,	1

ADDITIONAL USES
OF FIRE CLAY FLUE LINING

THE most common use of fire clay flue lining is, of course, in chimney construction, but due to the resistance of this lining to either sudden or slow changes in temperature and to the effects of smoke, fire, gases and acids, it is much used for other installations where these qualities prove of value.

Fire clay flue lining is used for lining the vent flues of gas heaters. In this connection "Dwelling Houses, a Code of Suggestions for Construction and Fire Protection Recommended by the National Board of Fire Underwriters" states:

> "Gas stoves, ranges and heaters, should be vented to a regular masonry chimney flue, the same as similar heating devices using other fuel. The size of each flue should be not less than 10 square inches.
>
> NOTE.—Gas appliances without flue connections when burning properly in a room produce an unpleasant and unhealthful atmosphere because they burn up the oxygen as well as discharge their products of combustion into the air.
>
> On the other hand it is a well known fact that such devices frequently burn improperly and they then discharge the deadly carbon monoxide into the atmosphere. This gas is inodorous and so insidious in its effect that persons breathing it may be unaware of their danger until they have become helpless. Many lives have been lost due to this cause, and frequently the victims were awake when attacked by the poison.
>
> Another reason for venting such devices, is that the unburned gas itself is poisonous and if for any cause the gas flame should be extinguished without cutting off the gas supply, it will soon make the atmosphere very dangerous to life as well as invite an explosion if any source of ignition is present. Many persons annually lose their lives due to this kind of poisoning.
>
> Such accidents usually occur when the victims are sleeping, for the escaping gas would be detected by the smell if people were awake."

Fire clay flue lining should be used for the ventilating flues or ducts over cooking ranges. Considerable heat is carried off by such vents and precautions should be taken against this heat affecting surrounding woodwork.

In school buildings, apartment houses, office buildings, industrial plants and many other locations the ventilating ducts supplying fresh air should be lined with fire clay flue lining. Practically all city building codes require that such a flue shall be of masonry and in most cases permit a thinner wall for the duct when a lining is used.

The vent ducts of chemical laboratories, of schools, colleges and industrial establishments should always be lined with fire clay flue lining. This applies especially to ducts over experiment hoods for those vents must often carry off gases and acid fumes which would destroy in a short time the ordinary duct constructed of other material.

The cold air ducts for warm air furnaces should be made of incombustible material and fire clay flue lining is especially suited for this purpose.

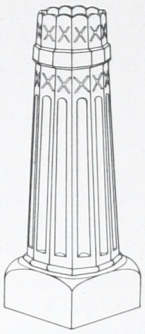
Where a large number of pipes and conduits must be installed in a building it is customary to build a special duct in the wall to carry them. This duct should be lined with fire clay flue lining. Building codes usually require this duct to be of masonry and make allowances in the thickness of walls where flue lining is used.

All stone or brick hot air flues should be lined with flue lining as a special precaution. This is required by some building codes as a protection against leakage through mortar joints.

Chutes for ashes, coal or rubbish should also be lined with fire clay flue lining.

These are only a few suggestions for the use of this valuable building material. Others will occur to every architect and builder.

CHIMNEY TOPS

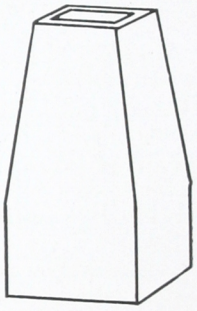


A

In European architecture, the chimney formed one of the most decorative features of any structure and recent American buildings are utilizing this thought in much the same way. One of the ancient means of decoration was by the use of chimney tops or chimney pots as they are sometimes called from the fact that they were formerly made of pottery.

Chimney tops have always, however, had a practical as well as an ornamental value for by adding height to a chimney they increase the draft. The choice of style depends upon the individual taste, type of building or chimney and size of the flue lining.

It is most important that the utmost care be exercised in selecting a chimney top of proper size. As practically all tops are smaller than the flue lining one of adequate cross-sectional effective area should be chosen in order that the draft shall not be reduced.

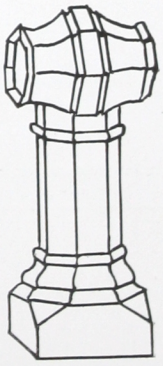


B

Chimney tops are made of fire clay which is not affected by heat and will not crack from changes in temperature. They are not limited to use on new structures but can well be placed on old chimneys and buildings.

The tops are set so as to cover the flue lining in the chimney and one top is required for each flue. A rich cement mortar should be used in setting the tops and should be graded away from the tops to the outside of the chimney to provide a wash.

The Windguard style greatly improves the draft because the air currents striking the chimney or roof are deflected upward through the windguard and out at the top. The hooded types are intended to prevent down drafts into the chimney as well as rain or snow from entering the flue.



C

Table of Chimney Tops

No.	Height Feet	Base Inches	Inside Flue Dimensions, Inches	Approximate Weight, Pounds
A	3	13 x 13	7 dia.	110
B	2	8½ x 8½	8 x 8	60
C	2½	13 x 13	9 x 9	67

CHIMNEY PIPE

For certain uses chimney pipe is popular and when properly erected, furnishes a convenient substitute for a masonry chimney. Among the uses to which chimney pipe may be put are: Contractors' shacks and temporary buildings of all kinds, bungalows, summer camps, etc. In some parts of the country local conditions make the use of chimney pipe advisable but such should never be used where it is possible to erect a masonry, lined chimney for the fire hazard with any chimney pipe is admittedly great. The directions given here will reduce this danger to a considerable extent if carefully followed.

Chimney pipe should not be erected inside a building as the points where the pipe pass through the floors and roof are especially dangerous. The pipe should be carried to a firm foundation on the ground and should not be supported on brackets or merely wired. Such construction should be severely penalized for it endangers not only the property upon which it is erected but all neighboring buildings. All joints should be carefully filled with cement mortar. Strap irons should be placed around the pipe and fastened to the outside wall to hold the pipe securely in place.

> "Chimney pipe is made of the same mixture of clays as flue lining and is thoroughly burned to withstand heat and cold, gases, acids, smoke and varying temperatures. It is made with socket for joint connections and in various fittings for use inside or outside of temporary or permanent buildings, where regular brick chimneys are not practicable."

The tables below give the sizes of the various types of chimney pipe illustrated in Figure 36. Anchor bonnets and chimney bases are made 6 inches, 7 inches, and 8 inches in diameter.

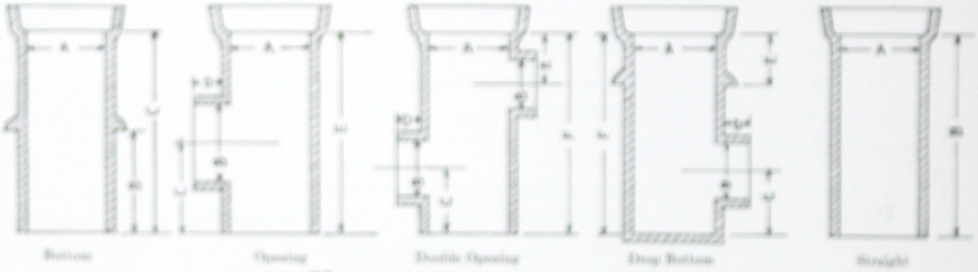


FIG. 36. STANDARD TYPES OF CHIMNEY PIPE.

Standard Dimensions of Chimney Pipe

STRAIGHT STOVE PIPE

Dia. Ins.	6	7	8
Length	2 ft.	2 ft.	2 ft.

STOVE PIPE FITTINGS

Bottoms

A—Inches	B—Inches	C—Feet
6	14	2
7	14	2
8	14	2

Openings

A, Inches	B, Inches	C, Inches	D, Inches	E, Feet
6	6	8	2½	2
7	7	8	2½	2
8	6	8	2½	2
8	8	8	2½	2

Double Openings

A—B Inches	C, Inches	D, Inches	E, Inches	F, Feet
6 x 6	8	2½	8	2
7 x 7	8	2½	8	2
8 x 6	8	2½	8	2
8 x 8	8	2½	8	2

Drop Bottoms

A, Inches	B, Inches	C, Inches	D, Inches	E, Inches	F, Feet
6	6	8	2½	4	2
7	7	8	2½	4	2
8	6	8	2½	4	2
8	8	8	2½	4	2

SPECIFICATION

for

BRICK CHIMNEYS WITH FIRE CLAY FLUE LININGS

as recommended by the

EASTERN CLAY PRODUCTS ASSOCIATION

(See "Short Form" at end)

(This specification conforms to all requirements set forth in this publication and in the Ordinance of the National Board of Fire Underwriters and in the Proposed Code of the American Society of Heating and Ventilating Engineers.)

This specification is written for one or more chimneys constructed of brick either singly or in connection with walls, fireplaces, etc. in any building. Where materials other than brick are to be used, it will serve as a basis in which such changes as are necessary may be made.

In the case of other materials than brick, the various points concerning good practice mentioned on Page 15 should be considered when specifying. These are from Pages 25 and 26, "Recommended Minimum Requirements for Small Dwelling Construction," the 1923 Report of the Building Code Committee of the U. S. Department of Commerce, to which this specification also conforms.

(1) BRICK

(a) All brick shall be good, sound, hard, well burned common brick. Brick shall be well wetted just before laying, if laid in dry, warm weather, or shall be perfectly dry if laid in cold weather.

(b) (If face brick or fire brick are to be used for any exposed work, stipulate the kind here, or elsewhere.)

(2) MORTAR

(a) Mortar for all free standing chimneys (and for fireplaces, breasts or other portions thereof) and for all chimneys above roofs shall be proportioned as follows: Two bags, 200 pounds, of Portland cement and one bag, 50 pounds, of dry hydrated lime thoroughly mixed dry, three times this volume of clean sharp sand, and sufficient water. All shall be well tempered to an even color.

(b) Mortar for chimneys forming parts of walls (and for breasts, fireplaces, hearths or other portions thereof) is to be as elsewhere specified for brickwork of walls.

(3) FIRE CLAY FLUE LININGS

(a) Fire clay flue linings shall be manufactured from suitable refractory clay, either natural or compounded, which has a softening point not lower than 1994 degrees Fahrenheit (Segar Cone 03) and shall be adapted to withstand high temperatures and flue gases.

(b) All flue linings shall be of the nearest stock size commercially obtainable to the sizes shown or marked on the drawings unless the same are stated to be made of special size to order for the particular installation shown.

(c) A certificate shall, if required, (or upon request), be furnished by the manufacturer stating that the flue lining supplied is in accordance with these specifications.

(4) CONSTRUCTION

(a) Build all chimneys (chimney breasts, fireplaces, hearths, etc.) to dimensions, forms, sizes, heights and thicknesses shown on drawings.

(b) Bricks shall be laid in the best and most workmanlike manner with full beds and full slushed joints, leaving no voids or empty spaces in the walls, and all shall be built perfectly straight and true to line on all faces.

NOTES

(a) If it is desired to go into detail regarding brick the Standard Specifications for Building Brick, Serial Designation C 21-20 of the American Society for Testing Materials will provide technical data, which may be amended to suit the brick commercially available in conformity with local good practice.

(a) For detailed data regarding mortar, see Page 15. It is suggested that all cements and limes shall conform to the standard specifications for such materials issued by the American Society for Testing Materials.

(a) These requirements are those contained in the "Ordinance for Construction of Chimneys" of the National Board of Fire Underwriters, 1921.

(b) Care should be taken that only standard sizes are shown or used, as this reduces the cost and facilitates prompt delivery.

(a) For further data regarding chimney construction see Pages 12 to 18.

(c) All flues shall be lined their entire height with fire clay flue linings starting at bottom of each flue above clean-out space (and at top of each smoke chamber over fireplaces) and extending 4″ above the top course of brick. No broken flue linings shall be used. Any change in direction shall be accomplished by carefully chipping off the ends of linings.

(c) See illustrations on Pages 16 and 23. For recommended method of chipping flue linings, see Page 5.

(d) All flues shall be independent of one another, but where the plans require that flues be built without a "withe" or dividing walls, joints of the linings shall be staggered at least 7″.

(d) See text and drawings on Pages 12, 13 and 14.

(e) Leave openings for all stovepipe holes and any registers where indicated or required and furnish and neatly build in fire clay flue rings of the proper sizes for all pipes entering flues.

(e) See text and illustrations on Pages 16 and 17.

(f) Clean-out openings shall be provided and set at bases of all flues, (except for fireplaces) each to be full width of flue. For each furnish and set a cast iron frame, well anchored, fitted with a tight closing cast iron door.

(f) See text and illustrations on Pages 16 and 17. If fireplaces are a part of the building for which this specification is used and metal frames or fire clay flues for ash drops are desired this will serve as a reminder that they should be called for.

(g) Each length of lining shall be set in place and the brick laid around it and under no circumstances shall more than three courses of the brick chimney wall be laid before the flue lining is inserted.

(h) All linings shall be laid with absolutely full joints of the mortar before specified, carefully pointed and smoothed on inside. The space between flue linings and enclosing walls shall be slushed full with mortar as each course of brick is laid.

(i) In the case of any flue which is built with an offset, a bag of burlap or similar material attached to a rope and filled with excelsior or similar material tightly fitting the flue shall be inserted below the first offset and drawn up as each few sections of flue lining are installed.

(i) This is to prevent mortar droppings from accumulating, as explained on Page 15.

(j) A wash of rich cement mortar having a slightly concave surface shall be laid on top of the chimney tapering off from 2″ thick against the flue lining.

(k) Build in all flashings as shown and elsewhere specified, carefully construct or set any caps shown, thoroughly clean down any exposed brickwork and leave everything finished and complete.

(5) SMOKE TEST

(a) Before the scaffolding is removed from around any chimneys and before any chimney walls or breasts are plastered, but not until after the mortar has seasoned, each flue shall be given a separate and thorough smoke test by the mason contractor. The tests shall be made in the presence of the mason contractor, the heating contractor and the architect or their representatives.

(a) For further data regarding smoke test, see Page 18.

(b) Leaks into adjacent flues shall be especially looked for and not more than one flue shall be tested at one time.

(c) Any leaks which may develop shall be promptly made tight before the chimney work will be accepted as satisfactory.

"SHORT FORM" SPECIFICATION

for

BRICK CHIMNEYS WITH FIRE CLAY FLUE LININGS

The following paragraph is suggested for inclusion in the Architect's Specification in lieu of the complete form preceding.

Furnish all materials and labor necessary for the complete construction of all chimneys (breasts, fireplaces, hearths, etc.) shown on the drawings. The same to be in accordance with the "Specification for Brick Chimneys with Fire Clay Flue Linings" as contained in "Flues and Flue Linings" issued 1924, by the Eastern Clay Products Association, Philadelphia, Pa. which are hereby made a part of this specification, including fire clay lining throughout each flue, which shall be given a smoke test and proved tight before acceptance of the work.

COMBUSTION
AND RELATED DATA ON FUELS

The combustion of fuels provides heat, light and much of the power for household purposes. The sources of this heat, light and power are of financial importance to the average householder since usually 5% or more of his income is expended for them either directly or indirectly.

The most commonly used fuels for household operations are of three groups; (1) Solid fuels, such as coal or wood; (2) Liquid fuels, such as kerosene or fuel oil; and (3) Gaseous fuels, such as manufactured gas, natural gas or acetylene.

All common fuels owe their fuel value to two elements, carbon and hydrogen, which occur usually in combination with each other and sometimes with other elements which do not add to the heat produced.

The "Combustion" or "Burning" of a substance, whether it be coal, wood, oil or gas, is the very rapid chemical combination of two or more elements, accompanied by the production of heat and light. The atoms of some elements have a very great attraction for those of certain other elements. When these elements are brought in contact under favorable conditions, the atoms rush together with such force that heat and light are produced.

Oxygen is one of the elements which has a great attraction for nearly all the other elements. It has a particular liking for carbon, and whenever these two elements come into contact at a sufficiently high temperature, they combine with great rapidity, giving off light and heat.

Coal is chiefly made up of carbon and hydrogen and when the temperature of coal is raised, the atoms of these elements combine with those of the oxygen taken from the air. This rapid combination is known as combustion.

The hydrogen of the coal unites with the oxygen of the air, and forms water vapor which usually passes off as steam with the smoke. If the combustion is complete, the carbon is united to form carbon dioxide. If, however, the burning is incomplete, the carbon may unite with only half its capacity of oxygen forming carbon monoxide. This is the so-called "furnace gas" and is most dangerous, as a sufficient amount when inhaled may cause fatal asphyxiation.

Carbon when alone, burns as a solid, but hydrogen and practically all its combinations with carbon burn with a flame, however, the combination of carbon and oxygen at first forms a gas (carbon monoxide), which is able to combine with more oxygen. This is accomplished by further burning to form carbon dioxide. This second burning is usually invisible but may sometimes be noticed in the form of a blue flame over a bed of hot fuel in a fireplace or furnace using hard coal or coke.

The theoretical amount of air required for complete combustion is readily calculated when the ultimate analysis of the fuel is known. Without entering into a discussion of the methods by which this may be figured, the following formula taken from "The Complete Line" of the United States Radiator Corporation may be found useful.

$$A = 34.56\left\{\frac{C}{3} + \left(H - \frac{O}{8}\right) + \frac{S}{8}\right\}$$

When A = weight, pounds of dry air required per pound of fuel; C, H, O and S = Proportional part of dry weight of carbon, hydrogen, oxygen and sulphur in the fuel. $\frac{O}{8}$ = Proportional part of Hydrogen supplied with Oxygen from the fuel itself.

The following example from the same book shows the application of the above formula:

Ultimate Analysis of Coal selected is given as:—

Combustibles 88.5% { Carbon—80% / Hydrogen— 4% / Oxygen—3% / Sulphur—1.5% }

Non-combustibles 11.5% { Moisture—5% / Non-combustible—6.5% }

Substituting the values of C, H, O and S in the formula:

$$A = 34.56\left\{\frac{0.80}{3} + \left(0.04 - \frac{0.03}{8}\right) + \frac{0.015}{8}\right\} = 10.5$$

pounds, the theoretical weight of dry air necessary to burn one pound of coal as fuel.

As water and ash must be treated as incombustibles, the total incombustible in the analysis is 11.5%. Therefore, the total amount of air required per pound of combustible is

$$\frac{10.5}{.885} = 11.87 \text{ pounds.}$$

As stated in "Mechanical Equipment of Buildings, Vol. 1, Heating and Ventilating" by Harding and Willard from which valuable work much of foregoing is taken.

"The calculations for air required presuppose that

each and every particle of oxygen is brought into intimate contact with the combustible.

"Practically, this is impossible, due to the large amount of inert nitrogen present, variations in the fuel bed, the interference of clinker and ash, which cannot be removed as soon as formed.

"It is therefore, necessary to provide an *excess of air* when burning coal under either natural or forced draft, amounting to approximately 50 to 100% of the net calculated amount or about 18 to 24 lb. per pound of coal.

"Less air results in imperfect combustion and smoke, while an excess cools the fire and setting and carries away large quantities of heat in the flue gases."

ACKNOWLEDGMENTS

The authors of this publication desire to record here their grateful appreciation of the assistance received in the preparation of this document from architects, engineers, clay products manufacturers, heating appliance manufacturers, builders and others, as well as from governmental departments, associations and other bodies.

Wherever possible the compilers have consulted and drawn upon well recognized publications and other reliable data and wish to give credit to the authors and publishers of such works.

Many of these documents and authorities are referred to throughout the text and others are listed here.

Sources of Information:

American Society of Heating and Ventilating Engineers.
American Society for Testing Materials.
American Institute of Architects.
Associated Tile Manufacturers.
Common Brick Manufacturing Association.
National Board of Fire Underwriters.
National Boiler and Radiator Manufacturers Association.
National Fire Protection Association.
National Warm Air Heating and Ventilating Association.
Kidder Nolan, Architects and Builders Handbook.
Building Construction and Superintendence, Part 1, Masons' Work.
Lefax Data Sheets.
Mechanical Equipment of Buildings, Vol. 1 Heating and Ventilation—Harding and Willard.
Ventilation and Heating—Billings.
Mechanical Equipment of Federal Buildings.—Thompson.
U. S. Dept. of Agriculture, Farmers' Bulletin No. 1230, "Chimneys and Fireplaces."—A. M. Daniels.
Journal of the American Society of Heating and Ventilating Engineers.
Purdue University:
Bulletin No. 2 "House Construction that Reduces Heating Costs."—James D. Hoffman.
University of Illinois:
Circular No. 4, "The Economical Purchase and Use of Coal for Heating Homes with Special Reference to Conditions in Illinois."—Engineering Experiment Station.
Bulletin No. 128, "The Ignition Temperature of Coal."—Ray W. Arms.
Bulletin No. 120, "Investigation of Warm Air Furnaces and Heating Systems."—Willard-Kratz-Day.
International Correspondence Schools:
Building Trades Handbook.
Steam Engineers' Handbook.
Mechanics' Handbook.
Heating and Ventilating Magazine.
American Architect.

INDEX AND CHECKING LIST

A

PAGE

Acknowledgments 30
Additional Uses of Fire Clay Flue Linings 24
Advantages of Flue Linings . . . 8, 10
Altitude—Effect on Flue Size . . . 11
Area—Effective, of
Rectangular Flue Linings 11
Round Flue Linings 11
Area—Reduction of Capacity When Used for More Than One Appliance 11
Ash Slide—Construction of 21

B

Brick Chimneys with Fire Clay Flue Linings
Complete Specification for . . . 27
Short Form Specification for . . 28

C

Carload Quantities
Rectangular Flue Linings 6
Round Flue Linings 7
Chamber, Smoke 20
Chimney
Construction in Detail 12
Flues 8, 9
Footings for 15
Heights and Flue Sizes, Table of . 11
In General 10
Insulation of Woodwork from . 18
Location of 12
Mortar for Construction of . . . 15
Openings into 16
Pipe, Standard Dimensions of . . 26
Smoke Pipe Connections 17
Specification for 27
Supports for 15
Tops, Table of Sizes 25
Clean-out Doors, Location of . . . 16
Clogged Flues, Prevention of . . . 15
Combustion and Related Data on Fuels 29
Commercial Purposes, Flues for . 10
Concrete, Chimney Construction . . 15
Connections—Smokepipe and Chimney 17
Construction Details 14
Cross Sectional Area of
Rectangular Flue Linings 6
Round Flue Linings 7

D

Damper—Throat 21
Dimensions—Standard, of
Rectangular Flue Linings 6
Round Flue Linings 7
Draft 8

E

Eastern Clay Products Association . 32
Effect of
Altitude on Flue Sizes 11
Connecting More than One Appliance to Same Flue 16
Effective Area of
Standard Flue Linings
Rectangular 6
Round 7
Flues—General 8
Flues—Unlined 11
Minimum Required for Various Heating Devices, Etc 10
Formula for Computing, Required 11

PAGE

Engineering Dept., Services of Eastern Clay Products Association . 32
Excessive Flue Area 11

F

Fire Clay Flue Linings
Additional Uses of 24
Types of 5
Rectangular, Dimensions of . . . 6
Round, Dimensions of 7
Fireplace
Construction of 19
Dampers for 21
Flues for 10, 19
Flue Proportions for 19
In Party Walls 22, 23
Protection of Woodwork Around 21
Shape of 20
Smoke Shelf and Chamber . . . 20
Throat Construction 19
First Flue Lining—The 3
Flue Linings
Additional Uses of 24
Area
Effective 11
Inside and Outside
Rectangular Flue Linings . . 6
Round Flue Linings 7
Reduction of 11
Shell 6, 7
First, The 3
Formulae for Computing Required Area 11
Historical Data 3
8½″ x 13″ and over 10
8½″ x 13″ and under 10
Proportioning for Fireplaces . . . 19
Rectangular, Standard Dimensions 6
Round, Standard Dimensions . . 7
Shell Thickness and Area of
Rectangular Flue Linings . . . 6
Round Flue Linings 7
Sizes and Chimney Heights, Table of 11
Types of 5
Quantity per Carload 6, 7
Weight of 6, 7
Flue Rings, Standard Dimensions of 24
Flues
Chimneys, and 8
Chimneys and, In General . . . 10
Footings for Chimneys 15
Formulae for Computing Required Effective Flue Area 11
Fuels—Combustion and Related Data on 29
Fireplaces 10
Origin of the 3
Power Plants and Commercial Purposes 10
Shapes of 8
Sizes of 9
Sizes Required Based on Capacity of Heater 11

H

Height of Chimneys 11
Historical Data on Flues 3
Hollow Tile, Chimney Construction 15

PAGE

I

Inside Dimensions of
Rectangular Flue Linings 6
Round Flue Linings 7
Insulation of Woodwork from Chimneys 18

L

Leakage, Smoke Test for 18
Lengths and Sizes of
Flue Linings 5
Rectangular Flue Linings 6
Round Flue Linings 7
Linings—see Flue Linings
Location of Chimneys 12

M

Member Companies, Eastern Clay Products Association 32
Mortar for Chimney Construction . 15

O

Openings in Flue Linings 5
Openings into the Chimney 16
Origin of the Flue 3
Outside Dimensions of
Rectangular Flue Linings 6
Round Flue Linings 7

P

Permissible Variation in Sizes of
Rectangular Flue Linings 6
Round Flue Linings 7
Plain Flue Linings 5
Power Plants—Flues for 10
Proportioning the Flue for
Fireplace 19
Heating Appliances 11
Protection of Woodwork Around Fireplaces 21
Purpose of The Eastern Clay Products Association 32

Q

Quantities, Carload
Rectangular Flue Linings 6
Round Flue Linings 7

R

Rectangular Flue Linings—Standard Dimensions of 6
Reduction of
Flue Capacity when Used for More than One Appliance . . 11
Excessive Flue Area 11
Round Flue Linings—Standard Dimensions of 7

S

Services of The Eastern Clay Products Association 32

PAGE

Shapes of
Flues 8
Fireplaces 20
Shell-thickness of
Rectangular Flue Linings 6
Round Flue Linings 7
Short Form Specification 28
Sizes of Flues 9
Sizes, Standard of
Rectangular Flue Linings 6
Round Flue Linings 7
Sizes, Flue and Chimney Heights, Table of 11
Smokepipe and Chimney Connections 17
Smoke Shelf and Chamber 20
Smoke Test for Leakage 18
Specification for Brick Chimneys with Fire Clay Flue Lining . . 27
Specification—Short Form 28
Standard Dimensions of
Flue Rings 24
Chimney Pipe 26
Rectangular Flue Linings 6
Round Flue Linings 7
Stone Chimney Construction . . . 15
Stove Pipe
Straight 26
Fittings 26
"Thimbles" 24
Straight Stove Pipe 26
Supports for Chimneys 15

T

Table of
Chimney Tops 25
Flue Sizes and Chimney Heights . 11
Standard Sizes
Rectangular Flue Linings . . . 6
Round Flue Linings 7
Test for Smoke Leakage 18
Throat
Construction 19
Damper 21
Tops, Chimney 25
Tudor Brick Chimneys, England 16th Century 8
Two Fireplaces Built Back to Back on Brick Party Wall 21
Types of Fire Clay Flue Linings . . 5

V

Variation, Permissible, in Sizes of
Rectangular Flue Linings 6
Round Flue Linings 7
Vent Ducts, Flue Linings for . . . 24
Ventilated Collars for Smoke Pipes 17

W

Weight
Rectangular Flue Linings 6
Round Flue Linings 7
"Withe" Construction 12, 13
Woodwork
Insulation from Chimneys 18
Protection Around Fireplaces . . 21

THE EASTERN CLAY PRODUCTS ASSOCIATION

Purpose, Services and Member Companies

A NUMBER of the large manufacturers of clay products in the territory east of the Mississippi River, feeling the necessity as well as the desirability of having an organization which would be qualified to furnish the consumer of clay products with that better service which is the aim of all progressive manufacturers, formed the Eastern Clay Products Association. The primary purpose of this Association is service to the purchaser and user of clay products, whether these products be flue linings, sewer pipe, wall copings or any of the many other types of clay ware manufactured by the member companies.

The Association maintains an Engineering Department, the services of which are freely available for advice and suggestions as to the best and most efficient use of clay products. Through its officers and technical staff it has representation on and takes part in the work of important committees of such national organizations as the American Society for Testing Materials, American Ceramic Society, National Fire Protection Association and others, co-operating in every way possible to improve methods of manufacture and construction.

These facilities are freely offered to all architects, engineers, contractors and others in the hope that they will afford all those interested the latest and most authoritative information regarding the proper utilization of clay products.

Member Companies

The Buckeye Fire Clay Company
Uhrichsville, Ohio.

The Cambria Clay Products Company
Blackfork, Ohio.

The Crouse Clay Products Company
Akron, Ohio.

The Dennison Sewer Pipe Company
Dennison, Ohio.

The East Ohio Sewer Pipe Company
Irondale, Ohio.

The Evans Pipe Company
Uhrichsville, Ohio.

The Junction City Sewer Pipe Company
Junction City, Ohio.

The Logan Clay Product Company
Logan, Ohio.

Patton Clay Manufacturing Company
Patton, Pa.

The Pennsylvania Clay Products Company
West Winfield, Penna.

Portland Stone Ware Company
49 Federal Street, Boston, Mass.

The Robinson & Sons Sewer Pipe Company
Uhrichsville, Ohio.

The Robinson Clay Products Company
Akron, Ohio.

The Robinson Clay Product Company of Penna.
Clearfield, Penna.

The Romig Clay Product Company
Uhrichsville, Ohio.

The Ross Clay Products Co., Inc.
Uhrichsville, Ohio.

St. Marys Sewer Pipe Company
St. Marys, Penna.

The Wolf-Lanning Clay Company
Dennison, Ohio.